U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB80-118706

Cost Effectiveness Model for Pollution Control at Coking Facilities

PEDCo-Environmental, Inc, Cincinnati, OH

Prepared for

Industrial Environmental Research Lab, Research Triangle Park, NC

Aug 79

United States
Environmental Protection
Agency

Industrial Environmental Research
Laboratory
Research Triangle Park NC 27711

EPA-600/2-79-185
August 1979

PB80-118706

Research and Development

EPA

Cost Effectiveness Model for Pollution Control at Coking Facilities

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into nine series. These nine broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The nine series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development
8. "Special" Reports
9. Miscellaneous Reports

This report has been assigned to the ENVIRONMENTAL PROTECTION TECHNOLOGY series. This series describes research performed to develop and demonstrate instrumentation, equipment, and methodology to repair or prevent environmental degradation from point and non-point sources of pollution. This work provides the new or improved technology required for the control and treatment of pollution sources to meet environmental quality standards.

EPA REVIEW NOTICE

This report has been reviewed by the U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policy of the Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-79-185	2.	3. RECIPIENT'S ACCESSION NO. PB 80 118706
4. TITLE AND SUBTITLE Cost Effectiveness Model for Pollution Control at Coking Facilities		5. REPORT DATE August 1979
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) William F. Kemner		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS PEDCo Environmental, Inc. 11499 Chester Road Cincinnati, Ohio 45242		10. PROGRAM ELEMENT NO. 1AB604
		11. CONTRACT/GRANT NO. 68-02-2603, Task 44 and 68-02-3074, Task 6
12. SPONSORING AGENCY NAME AND ADDRESS EPA, Office of Research and Development Industrial Environmental Research Laboratory Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED Task Final; 9/78 - 7/79
		14. SPONSORING AGENCY CODE EPA/600/13

15. SUPPLEMENTARY NOTES IERL-RTP project officer Twidwell is no longer with EPA; for details contact Norman Plaks, Mail Drop 62, 919/541-2733.

16. ABSTRACT The report describes a computer model, developed for coking facilities, that allows the user to determine the optimum mix of pollution control devices to achieve a specified reduction in pollutant emission at the minimum annualized or capital cost. The computer program calculates and displays: the associated cost for each emission control; the total capital and annualized cost for the optimum mix of controls; and the emission levels in pounds of pollutant per ton of coal and tons of pollutant per year for each of the four pollutant types (total suspended solids, benzene-soluble organics, benzo(a)pyrene, and benzene). The program can consider 20 emission sources and 9 control options for each emission source.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Organic Compounds	Pollution Control	13B
Coking	Pyrenes	Stationary Sources	13H
Iron and Steel Industry		Suspended Solids	11F
Cost Effectiveness		Benzo(a)pyrene	14A
Mathematical Models			12A
Benzene			07C

18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 297
	20. SECURITY CLASS (This page) Unclassified	22. PRICE PC A13 MF A01

EPA Form 2220-1 (9-73)

EPA-600/2-79-185

August 1979

Cost Effectiveness Model for Pollution Control at Coking Facilities

by

William F. Kemner

PEDCo Environmental, Inc.
11499 Chester Road
Cincinnati, Ohio 45242

Contract No. 68-02-2603, Task No. 44
and Contract No. 68-02-3074, Task No. 6
Program Element No. 1AB604

EPA Project Officer: Larry G. Twidwell

Industrial Environmental Research Laboratory
Office of Environmental Engineering and Technology
Research Triangle Park, NC 27711

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Washington, DC 20460

1-A

DISCLAIMER

This report is furnished to the Environmental Protection Agency by PEDCo Environmental, Inc., Cincinnati, Ohio, in fulfillment of EPA Contract No. 68-02-2603, Task No. 44 and EPA contract No. 68-02-3074, Task 6. It describes the initial development and use of a cost optimization model for control of emissions from coke ovens. The cost model has been developed so that it will accommodate new information that becomes available on control cost, control systems, and emission levels. The data presented in this report and now used in the model are considered to be the best currently available. Because some areas of knowledge are continually developing, however, some engineering estimates are used to facilitate the development and refinement of the model.

The contents of the report reproduced herein are as received from the contractor. The opinions expressed are those of the authors and do not necessarily reflect the views of the EPA. Mention of company or product names is not to be considered as an endorsement by the authors or the EPA.

TABLE OF CONTENTS

Page

Disclaimer ii

List of Figures v

List of Tables vii

Acknowledgement viii

1.0 Introduction 1

References 3

2.0 Model Structure 4

2.1 Data Requirements 6
2.2 Control Cards 13

3.0 Emission Factors 20

3.1 Source 1--Larry Car Charging 22
3.2 Source 2--Coke Pushing Operations 25
3.3 Source 3--Quench Towers with Clean H_2O; Source 16--Without Clean H_2O 27
3.4 Source 4--Door Emissions 29
3.5 Source 5--Topside Leaks 31
3.6 Source 6--Old Combustion Stack; Source 15--New Combustion Stack 31
3.7 Source 7--Coke Handling 32
3.8 Source 8--Coal Preheat 33
3.9 Source 9--Coal Preparation 34
3.10 Source 10--Coal Storage 35
3.11 Source 11--Pipeline Charging 35
3.12 Source 12--Redler Conveyor Charging 37
3.13 Source 13--Hot-Larry-Car Charging 39
3.14 Source 14--Byproduct Recovery Plants 39

References 41

TABLE OF CONTENTS (continued)

Page

4.0 Cost Methodology 44

4.1 Standards and Assumptions 44
4.2 Procedure for Cost Estimating 49

References 57

5.0 Control Systems 58

5.1 General Specifications 58

References 81

6.0 Battery Data Base (Dataset 3) 82

References 96

7.0 Model Formulation 97

8.0 Results 101

Appendix A - Example Computer Printouts for Cost Functions Presently Included in Model A-1

Appendix B - Example Computer Printout for Cost Update Program B-1

FIGURES

No.		Page
1	Schematic Diagram of Overall Computing Scheme	5
2	Card Format for Emission Factors--Dataset 1	8
3	Card Format for Cost Function Coefficients and Efficiency	12
4	Card Formats for Datasets 4, 5, and 6	14
5	Sample Output Report of Coke Oven Optimization Model	15
6	Format for the Control Cards	16
7	Relationship of Emission Sources in a Typical Byproduct Coke Plant	45
8	Flow Plan and Material Balance of a Representative Coke Byproduct Recovery Plant	46
9	Worksheet for Estimating Capital Costs	52
10	Cross Section of Coke-side Shed	62
11	Conventional Quench Tower Baffles	65
12	Simplified Pictorial Diagram of a Dry Quenching System	66
13	Door Hood Arrangement	68
14	Dust-suppression Spray System at Car Dump	73
15	Permanently Installed Spray Stanchions Around Perimeter of Coal Piles	75
16	Total Particulate Emissions from Coke Quenching	77
17	Coke Plant Wastewater Treatment System	80

FIGURES (continued)

No.		Page
18	Battery Data Card Format	90
19	Capital Cost of Control Options for Wet Coal Charging	106
20	Cost Per Pound of Particulate Removal for Control Options for Wet Coal Charging	107
21	Total Annualized Cost as a Function of Overall Efficiency	114

TABLES

No.		Page
1	Summary of Uncontrolled Emission Factors	7
2	Control Options by Source	10
3	Relationships of Size and Other Parameters, Coke Oven Battery	48
4	Typical Items Included in Investment Costs for Control Devices	51
5	Annualized Operating Cost Factors for Control Systems	54
6	Rates Used in the Cost Model	55
7	Coke Plants Using Process Water for Quenching	79
8	Coke Oven Model - Battery Data Base	84
9	Plant ID Codes	91
10	Total Capital and Annualized Costs for Control Options	103
11	Total Uncontrolled Emissions	105
12	Model Output for Baseline of No Control	108
13	Model Output for 95 Percent Overall Particulate Reduction	109
14	Model Output for 80 Percent Overall Particulate Reduction	111
15	Model Output for 85 Percent Overall Particulate Reduction	112
16	Model Output for 90 Percent Overall Particulate Reduction	113
A-1	Cost Function Coefficients for Control Options	A-2

ACKNOWLEDGEMENT

Many individuals have been helpful in developing this report. Mr. Andrew Trenholm of Office of Air Quality, Planning and Standards (OAQPS) provided invaluable assistance in developing emission factor and control efficiency estimates and in reviewing control system specifications. Mr. John Pratapas of Economics Analysis Branch (EAB) reviewed the approach used for calculating capital and annualized cost estimates. The assistance of the Project Officer, Dr. Larry Twidwell, is also gratefully acknowledged.

Mr. William Kemner served as Project Director, and Dr. Terrance Briggs as Project Manager. Ms. Beth Fairbairn and Mr. Steve Tomes of PEDCo did the computer programming and Mr. Gary Saunders conducted much of the data development effort.

SECTION 1

INTRODUCTION

The characterization and control of coke oven emissions have been of intense interest and study for some 10 years. Originally, focus was directed primarily toward visible emissions because most coke oven emissions are fugitive in nature. As additional data became available on the complex chemical structure and health effects of both the particulate and gaseous emissions, however, attention shifted to the organic components contained therein. Because the environmental control of the coke oven process and its associated operations requires the evaluation of numerous options and because technology and new information are continually developing, the Environmental Protection Agency (EPA) contracted PEDCo Environmental, Inc., to develop a computer model that could calculate the cost and emission levels for any combination of controls. Even more important, the model should be able to calculate the lowest-cost mix of controls for the various sources to meet a given overall level of emissions. The model should also answer the reverse problem by calculating the lowest overall emission level that can be attained at a given total cost. The model may be used to optimize, i.e., minimize, either annualized cost or total capital costs.

Intended to be an engineering tool for evaluating various control strategies on a continuing basis, the model is designed to operate on the EPA computer at the National Computer Center in Research Triangle Park, North Carolina. It accommodates data on four key pollutants: particulate matter (defined herein as front-half--Method 5), benzene soluble organics (BSO), benzo-a-pyrene (BaP), and benzene. The model includes the coke oven battery, the coal storage and preparation steps, the quenching and coke screening operations, and the byproduct plant. It addresses both conventional batteries and preheated coal batteries. Various studies are under way to characterize the emissions from the byproduct operations, but the model now contains very limited information regarding this source.

The model utilizes three distinct types of data, referred to as "datasets." Each dataset can be updated and manipulated separately. Dataset 1 covers the uncontrolled emission rates for each pollutant, Dataset 2, capital and annualized costs and the control efficiency of various controls, and Dataset 3, the population of the coke oven batteries (e.g., battery height, capacity, and number of ovens).

Although a precise definition of the coke oven population was not a prime objective of this project, the definition provided by Dataset 3 is sufficiently comprehensive to be representative of both the metallurgical and foundry coke segments of the industry.

The model includes an auxiliary computer program that can update costs to account for such factors as inflation, changing utility rates, and changing labor costs.

The reader of this report is assumed to have a relatively comprehensive knowledge of coking operations and the concomitant emission problems and control schemes. The references at the end of this section are recommended reading for those who desire such background material.

REFERENCES FOR SECTION 1

1. Draft of Standards Support and Environmental Impact Statement, Volume I: Proposed National Emission Standards By-product Coke Oven Wet-coal Charging and Topside Leaks. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. June 1978.

2. Arthur D. Little, Inc. Steel and the Environment. A Cost Impact Analysis. May 1975.

3. Kemner, W., et al. Control of Emissions from Dry Coal Charging at Coke Batteries. Prepared for U.S. EPA under Contract 68-02-2603, Task 28, January 1979.

4. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. EPA-450/3-77-010. March 1977.

5. Barnes, T.M., H.W. Lownie, Jr., and J. Varga. Summary Report on Control of Coke Oven Emissions to the American Iron and Steel Institute. Batelle Columbus Laboratories. December 31, 1973.

SECTION 2

MODEL STRUCTURE

As shown in Figure 1, the coke model has four essential elements:

1. The data management element reads the required information, determines the mode of operation, and translates the input data into the proper format for the optimization element.
2. The optimization element calculates the lowest cost for achieving a given level of emissions or the lowest level of emissions that can be achieved at a given cost. Note that optimization is on one pollutant at a time; however, the results for other pollutants are calculated in each case.
3. The deterministic mode element calculates specific cases without regard to optimization, e.g., the total cost to industry for putting ESP's on all coke oven stacks.
4. The print element prints the output reports in the desired format.

It will be noted that the optimization model is built around the standard 80-column punched card. Although this approach is somewhat outdated by today's computer technology standards, it offers certain advantages at this stage of model development. The main advantage is that the user can actually keep the data cards in his posession and keep track of the data as they are changed. The entire system can later be converted to real time operation from a remote terminal.

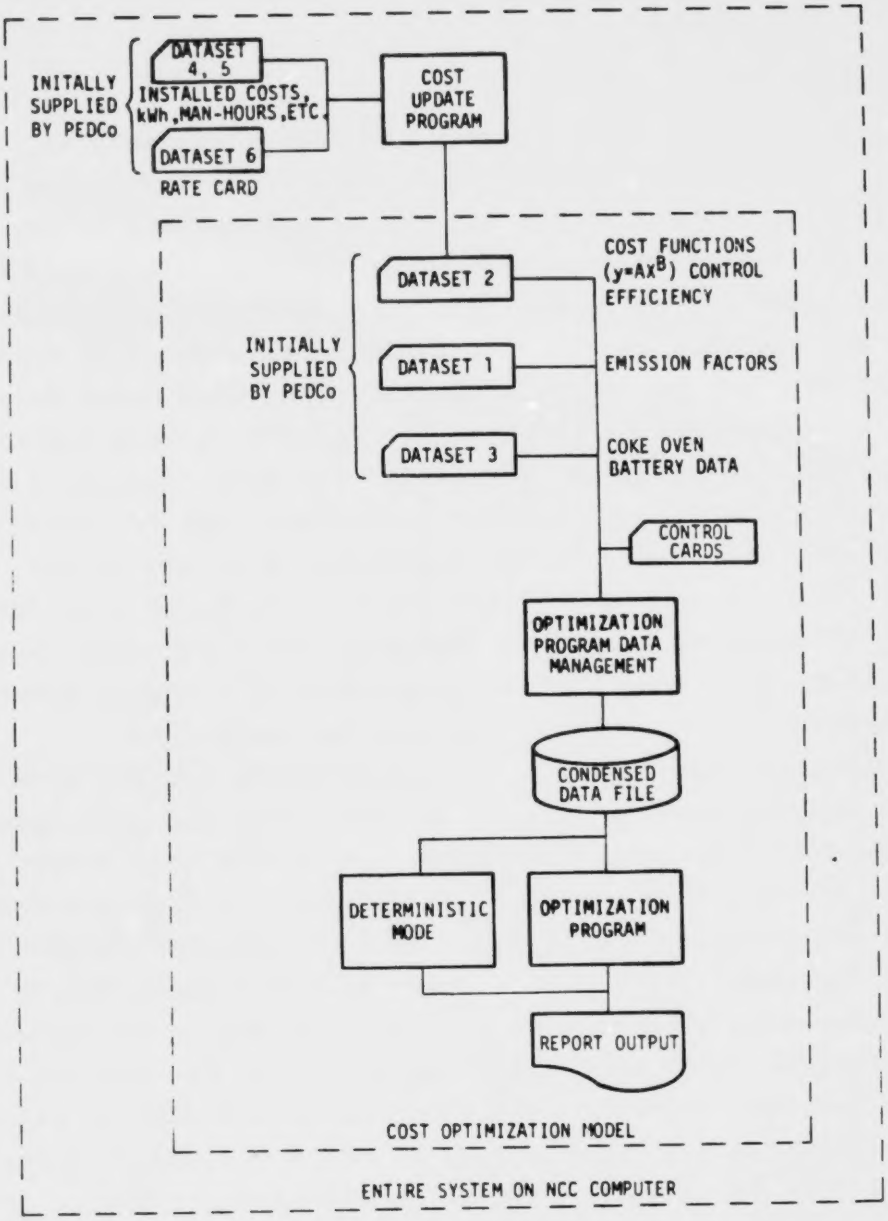

INITALLY SUPPLIED BY PEDCo
DATASET 4, 5
INSTALLED COSTS, kWh, MAN-HOURS, ETC.
DATASET 6
RATE CARD
COST UPDATE PROGRAM
DATASET 2
COST FUNCTIONS (y=AX^B) CONTROL EFFICIENCY
INITIALLY SUPPLIED BY PEDCo
DATASET 1
EMISSION FACTORS
DATASET 3
COKE OVEN BATTERY DATA
CONTROL CARDS
OPTIMIZATION PROGRAM DATA MANAGEMENT
CONDENSED DATA FILE
DETERMINISTIC MODE
OPTIMIZATION PROGRAM
REPORT OUTPUT
COST OPTIMIZATION MODEL
ENTIRE SYSTEM ON NCC COMPUTER

Figure 1. Schematic diagram of overall computing scheme.

2.1 DATA REQUIREMENTS

Emission Factors (Dataset 1)

Fourteen air emission sources and four pollutants are presently considered. A total of 64 uncontrolled emission factors are required because two sources have alternate factors. The emission factors used are shown in Table 1. It should be noted that data for coke oven emissions are very sparse for most sources and the factors shown in Table 1 represent only a starting point used for the purpose of proceeding with model development. The reliability of many of the factors is very low and is discussed more fully in Section 3. The term "uncontrolled" is not easily defined in the case of coke ovens, but for purposes of this project, it represents the conditions existing at the majority of batteries in the late 1960's. Although this definition still leaves much room for judgment, it eliminates totally uncontrolled conditions that could prevail if a coking process were operated with no concern whatever for emissions.

Because estimates of many of the emission factors have been based on limited data, provision has been made for easy updating to accommodate future refinements by use of the card format shown in Figure 2. The 16 cards (i.e., 14 sources, 2 with alternate factors) representing the emission factors comprise Dataset 1 input to the model (Figure 1). These emission factor cards also contain the space to write the name for the source for convenient identification. (The alphabetic names for new sources and control options that appear on the computer output must be entered into the computer using cards identified in the users' manual.) The derivation of emission factors is discussed in detail in Section 3.

Cost Functions (Dataset 2)

All cost functions are expressed as $Y = AX^B$, where Y is annualized cost in dollars and X is tons of coke capacity. Total capital cost is also provided as a function $Y = AX^B$. Capital and

TABLE 1. SUMMARY OF UNCONTROLLED EMISSION FACTORS (lb/ton of coal)

(See Section 3 for discussion of each factor)

Source code No.	Emission source	Pollutant			
		TSP[a]	BSO	BaP	Benzene
1	Larry car charge (wet coal)	1.0[b]	1.1[b]	0.002[c]	0.5[d]
2	Coke pushing[e]	2.0[f]	0.08[f]	4×10^{-5}[f]	0.006[f]
3	Quench, clean water	1.7[f,g]	1.7×10^{-3}[b]	1.4×10^{-4}[b]	3×10^{-5}[c]
4	Doors	0.4[b]	0.5[b]	0.003[b]	0.02[b]
5	Topside leaks	0.2[d]	0.25[d]	0.001[d]	0.005[d]
6	Combustion stack (old)[h]	1.3[d]	0.006[d]	6×10^{-5}[d]	0[d]
7	Coke handling	1.0[d]	0[d]	0[d]	0[d]
8	Coal preheat	7.05[b]	1.05[b]	3.9×10^{-4}[c]	0.014[c]
9	Coal preparation	0.5[d]	0[d]	0[d]	0[d]
10	Coal storage	0.15[d]	0[d]	0[d]	0[d]
11	Pipeline charge (dry coal)	0.016[d]	0.019[d]	3.5×10^{-5}[d]	0.008[d]
12	Redler conveyor (dry coal)	0.010[d]	0.006[d]	1.1×10^{-5}[d]	0.0049[d]
13	Hot larry car (dry coal)	0.017[d]	0.019[d]	3.5×10^{-5}[d]	0.008[d]
14	Byproduct	0[c]	0.3[c]	0[c]	0.2[c]
15	Combustion stack (new)[h]	0.13[d]	6×10^{-4}[d]	6×10^{-6}[d]	0[d]
16	Quench, dirty water	3.2[f,g]	6.4×10^{-3}[b]	3.1×10^{-4}[b]	2.6×10^{-4}[c]

[a] All TSP values **derived from the front half of Method 5 or an equivalent method.**

[b] One or more tests conducted, moderate confidence in accuracy.

[c] Test data available but inconclusive, low confidence in accuracy.

[d] No test data available. Emission factor calculated from other sources, very low confidence in accuracy.

[e] For dry coal charging, lower values may be appropriate (see text).

[f] Several tests conducted, good correlation between data, good confidence in numerical accuracy.

[g] Two cases are considered: "clean" water and "dirty" water. Existing data are used to select the appropriate emission factor.

[h] Emissions depend on the maintenance history and age of the battery. The term "new" designates a well maintained battery with effective patching and maintenance programs. The term "old" designates the opposite. The population is subdivided on the assumption that batteries under 15 years old are new and over 15 years old are old. This approach is questionable, but in the absence of site-specific data, it is a starting point. Sensitivity analysis can be used to investigate the significance of various assumptions.

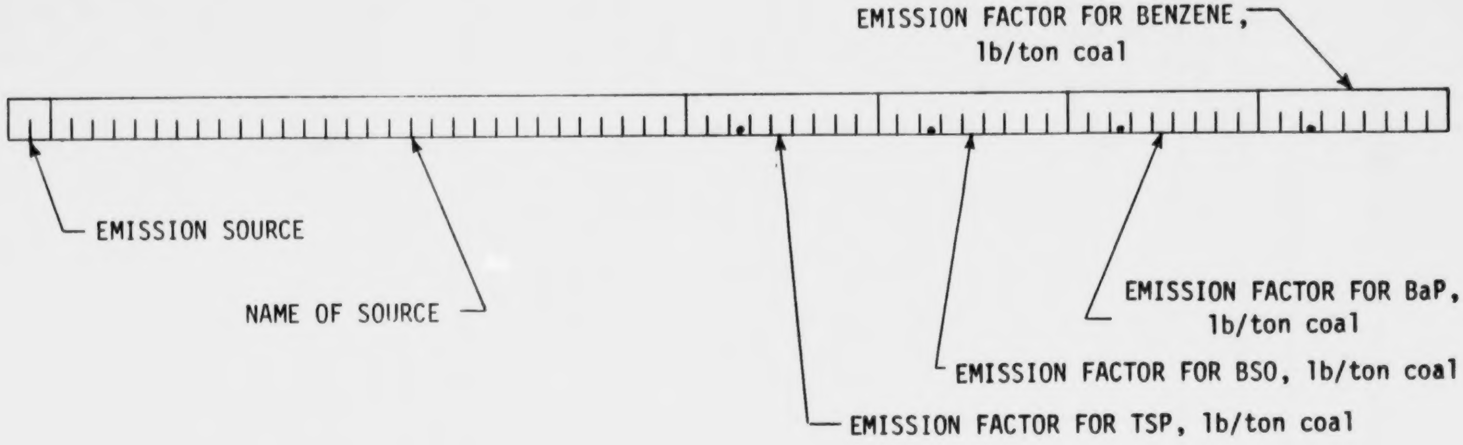

EMISSION FACTOR FOR BENZENE,
lb/ton coal
EMISSION SOURCE
NAME OF SOURCE
EMISSION FACTOR FOR BaP,
lb/ton coal
EMISSION FACTOR FOR BSO, lb/ton coal
EMISSION FACTOR FOR TSP, lb/ton coal

Figure 2. Card format for emission factors--Dataset 1.

annualized cost functions are provided for both new and retrofit installations.

The cost function matrix has the following dimensions:

Sources - Maximum of 20 (16 presently assigned)

Alternative control options--A maximum of nine per source, including uncontrolled

Table 2 lists the control options by source. The efficiencies shown are initial estimates only and are subject to change. The model provides for up to eight total control options for each source, but only a total of 41 are considered at this time. Although control efficiency is discrete in some cases and continuous in others, discrete levels have been used in the model for simplification. The total control option matrix capability is therefore 20 x 9, which produces a potential maximum of 180 "A" values and 180 "B" values for annualized and capital cost for both new and retrofit installations. Figure 3 shows the card format for A and B values. These cards are introduced as Dataset 2 (see Figure 1). As new control options are added or existing ones modified, the appropriate cost functions are added to Dataset 2. Most of the cost functions now in the model were calculated by PEDCo, using a separate computer program that is not part of the optimization model for coking facilities. The calculation of costs is discussed in detail in Sections 4 and 5.

Coke Oven Battery Data (Dataset 3)

This dataset contains the coke capacity, physical size, and existing control equipment information for each individual battery. It is described more fully in Section 6.

Cost Update Program

The cost update program is separate from the optimization model. Its purpose is to enable the user to recalculate annualized and capital costs by using different utility rates, labor rates, and overhead factors and accounting for inflation.

TABLE 2. CONTROL OPTIONS BY SOURCE

Source No.	Source	Control option No.[a]	Control option	TSP, % efficiency			BSO, % efficiency			BaP, % efficiency			Benzene, % efficiency			Remarks
				capture	removal	total	capture	removal	total	capture	removal	total	capture	removal	total	
01	Larry car charging	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Modified car, steam, boot	80.0	NA	80.0	80.0	NA	80.0	80.0	NA	80.0	80.0	NA	80.0	
		03	New car, steam, boot	99.0	NA	99.0	99.0	NA	99.0	99.0	NA	99.0	99.0	NA	99.0	
		04	Retrofit second main + option 03	99.5	NA	99.5	99.5	NA	99.5	99.5	NA	99.5	99.5	NA	99.5	
02	Coke pushing	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Controlled coking	60.0	NA	60.0	60.0	NA	60.0	60.0	NA	60.0	60.0	NA	60.0	19.0 h avg. coking time vs. 17.5 h base. Not appl. for foundry batteries
		03	Shed + ESP 95%	90.0	95.0	85.5	90.0	50.0	45.0	90.0	50.0	45.0	90.0	50.0	45.0	Shed options include 90% capture of one-half of door emissions
		04	Shed + scrubber 95% - 30 in. ΔP	90.0	95.0	85.5	90.0	55.0	49.5	90.0	55.0	49.5	90.0	55.0	49.5	
		05	Enclosed car	90.0	98.0	88.2	90.0	60.0	54.0	90.0	40.0	36.0	90.0	60.0	54.0	
		06	Shed + ESP 99%	90.0	99.0	89.1	90.0	50.0	45.0	90.0	50.0	45.0	90.0	50.0	45.0	
		07	Shed + scrubber 99% - 50 in. ΔP	90.0	99.0	89.1	90.0	60.0	54.0	90.0	60.0	54.0	90.0	60.0	54.0	
03	Quenching clean water	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Baffles	100.0	70.0	70.0	100.0	70.0	70.0	100.0	70.0	70.0	100.0	0.0	0.0	
		03	Diverted flow baffles	100.0	90.0	90.0	100.0	90.0	90.0	100.0	90.0	90.0	100.0	0.0	0.0	
		04	Dry quenching	100.0	98.0	98.0	100.0	99.0	99.0	100.0	99.0	99.0	100.0	99.0	99.0	Includes option 5 on source 2
04	Doors	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Cleaning and maintenance	60.0	NA	60.0	60.0	NA	60.0	60.0	NA	60.0	60.0	NA	60.0	
		03	High pressure water cleaning	80.0	NA	80.0	80.0	NA	80.0	80.0	NA	80.0	80.0	NA	80.0	Includes door cleaning machine
		04	Door hood and scrubber - 30 in. ΔP + 02	75.0	95.0	88.5	75.0	60.0	78.0	75.0	60.0	78.0	75.0	50.0	65.0	Option 6 is same as 4 but 1 side only[b]
		05	Door hood + scrubber - 60 in. ΔP + 02	85.0	98.0	93.3	85.0	70.0	83.8	85.0	70.0	83.8	85.0	60.0	72.0	Option 7 is same as 5 but 1 side only
05	Topside	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Luting and cleaning	90.0	NA	90.0	90.0	NA	90.0	90.0	NA	90.0	90.0	NA	90.0	Not applicable to pipeline batteries that are handled separately
		03	Luting and maintenance	95.0	NA	95.0	95.0	NA	95.0	95.0	NA	95.0	95.0	NA	95.0	
		04	New lids and castings + 02	97.0	NA	97.0	97.0	NA	97.0	97.0	NA	97.0	97.0	NA	97.0	

NA - Not applicable.

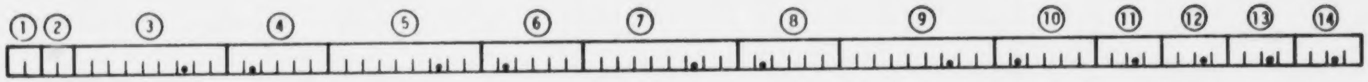
TABLE 2 (continued)

Source No.	Source	Control option No.[a]	Control option	TSP, % efficiency			BSO, % efficiency			BaP, % efficiency			Benzene, % efficiency			Remarks
				capture	removal	total	capture	removal	total	capture	removal	total	capture	removal	total	
06	Combustion stack -old	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Oven patching	100.0	80.0	80.0	100.0	80.0	80.0	100.0	80.0	80.0	100.0	80.0	80.0	
		03	Dry ESP 90%	100.0	90.0	90.0	100.0	50.0	50.0	100.0	50.0	50.0	100.0	50.0	50.0	
		04	Dry ESP 98%	100.0	98.0	98.0	100.0	60.0	60.0	100.0	60.0	60.0	100.0	60.0	60.0	
		05	Baghouse 98%	100.0	98.0	98.0	100.0	50.0	50.0	100.0	50.0	50.0	100.0	50.0	50.0	
07	Coke handling	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Enclosures + baghouse 99%	90.0	99.0	89.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	
08	Coal preheater	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Scrubber-15 in.	100.0	95.0	95.0	100.0	60.0	60.0	100.0	60.0	60.0	100.0	50.0	50.0	
		03	Dry ESP 95%	100.0	95.0	95.0	100.0	45.0	45.0	100.0	45.0	45.0	100.0	45.0	45.0	
		04	Scrubber-30 in.	100.0	98.0	98.0	100.0	60.0	60.0	100.0	60.0	60.0	100.0	50.0	50.0	
		05	Dry ESP 99%	100.0	99.0	99.0	100.0	50.0	50.0	100.0	50.0	50.0	100.0	50.0	50.0	
09	Coal preparation	01	Uncontrolled			0.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	
		02	Enclosure and baghouse-99%	98.0	99.0	97.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	
10	Coal storage yard	01	Uncontrolled	0.0	NA	0.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	
		02	Water truck	60.0	NA	60.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	
		03	Unload sprays & water truck	75.0	NA	75.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	
		04	Coal pile sprays	90.0	NA	90.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	
11	Pipeline charging	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Operation and maintenance	90.0	NA	99.0	99.0	NA	99.0	99.0	NA	99.0	99.0	NA	99.0	
12	Redler charging	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Operation and maintenance	99.0	NA	99.0	99.0	NA	99.0	99.0	NA	99.0	99.0	NA	99.0	
13	Hot larry car charging	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Operation and maintenance	99.0	NA	99.0	99.0	NA	99.0	99.0	NA	99.0	99.0	NA	99.0	
14	Byproduct plant	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Maintenance	NA	NA	NA	80.0	NA	80.0	80.0	NA	80.0	80.0	NA	80.0	
15	Combustion stack -new	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Oven patching	80.0	NA	80.0	80.0	NA	80.0	80.0	NA	80.0	80.0	NA	80.0	
16	Quenching - dirty water	01	Uncontrolled			0.0			0.0			0.0			0.0	
		02	Baffles	100.0	70.0	70.0	100.0	35.0	35.0	100.0	35.0	35.0	100.0	0.0	0.0	
		03	Clean water + 02	100.0	85.0	85.0	100.0	75.0	75.0	100.0	80.0	80.0	100.0	75.0	75.0	
		04	Diverted flow baffles + clean water	100.0	95.0	95.0	100.0	85.0	85.0	100.0	85.0	85.0	100.0	75.0	75.0	
		05	Dry quenching[c]	NA	99.0	99.0	NA	99.0	99.0	NA	99.0	99.0	NA	99.0	99.0	Includes option 5 on Source 2.

[a] These code numbers are also used to indicate existing control in columns 21-60 of the load card for data set 3 shown in Figure 4.

[b] Options 6 and 7 are used by the model when a shed is selected to avoid double accounting for capture of coke-side door emissions.

[c] The cost for this option in this case also includes the cost of water treatment for the water that otherwise would be used for quenching.



① EMISSION SOURCE
② CONTROL OPTION
③ A COEFFICIENT FOR ANNUALIZED COST OF RETROFIT SOURCES
④ B COEFFICIENT FOR ANNUALIZED COST OF RETROFIT SOURCES
⑤ A COEFFICIENT FOR TOTAL CAPITAL COST OF RETROFIT SOURCES
⑥ B COEFFICIENT FOR TOTAL CAPITAL COST OF RETROFIT SOURCES
⑦ A COEFFICIENT FOR ANNUALIZED COST OF NEW SOURCES
⑧ B COEFFICIENT FOR ANNUALIZED COST OF NEW SOURCES
⑨ A COEFFICIENT FOR TOTAL CAPITAL COST OF NEW SOURCES
⑩ B COEFFICIENT FOR TOTAL CAPITAL COST OF NEW SOURCES
⑪ TSP CONTROL EFFICIENCY
⑫ BSO CONTROL EFFICIENCY
⑬ BaP CONTROL EFFICIENCY
⑭ BENZENE CONTROL EFFICIENCY

Figure 3. Card format for cost function coefficients and efficiency.

The input to the cost update program consists of the capital cost and utility and labor requirements for three sizes of batteries (or plants as applicable). A rate card contains the various rates and factors that can vary. The program will extend rates, calculate overhead expenses and capital recovery, and finally, calculate regression equations for capital and annualized cost as a function of capacity, according to equations of the form:

$$Y = AX^B$$

This program is run only if new rates are needed. Figure 4 shows the card formats for the Datasets 4, 5, and 6 which are the input data to the cost update program. Appendix B contains an example run of the cost update program. The output cards of the cost update program represent the input cost function cards for the optimization model.

2.2 CONTROL CARDS

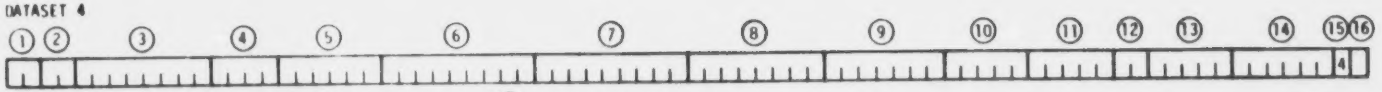
The model has three basic modes of operation:

1. Deterministic
2. Optimized cost, fixed emissions
3. Optimized emissions, fixed cost

The control cards serve as the interface between the user's "questions" and the model structure.

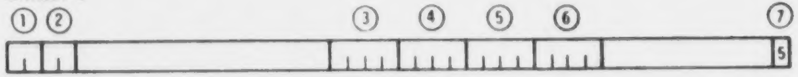
Mode 1 is the most straightforward. Its objective is to calculate the cost of a given strategy without regard to optimization. A control efficiency and a control option are specified for each source (or for one source). Figure 5 shows the output. The only reason the quenching and combustion stack sources appear twice is because two different uncontrolled emission factors are used for each in the model as described earlier. The costs and emissions for these sources are additive. Figure 6 shows the formats of the control cards. (Not all columns of the Number 1 card are necessary for Mode 1.)

DATASET 4



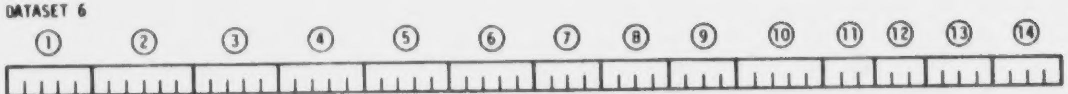
① EMISSION SOURCE
② CONTROL OPTION
③ CAPITAL COST FACTOR, $
④ RETROFIT FACTOR
⑤ SIZE, tons/yr
⑥ WATER, 1000 gal/yr
⑦ ELECTRICITY, kWh/yr
⑧ STEAM, 1000 lb/yr
⑨ FUEL, 1000 gal/yr
⑩ TOTAL DIRECT LABOR, h
⑪ SOLID WASTE, tons/yr
⑫ ESTIMATED LIFE OF UNIT, YEARS
⑬ MAINTENANCE MATERIAL COST, $$10^3$
⑭ SUPPLIES, $$10^3$
⑮ CARD CODE "4"
⑯ SIZE CODE 1 - SMALL PLANT
2 - MEDIUM PLANT
3 - LARGE PLANT

DATASET 5



① EMISSION SOURCE
② CONTROL OPTION
③ CONTROL EFFICIENCY, TSP (STARTS IN COLUMN 56)
④ CONTROL EFFICIENCY, BSO
⑤ CONTROL EFFICIENCY, BaP
⑥ CONTROL EFFICIENCY, BENZENE
⑦ CARD CODE "5" IN COLUMN 79

DATASET 6



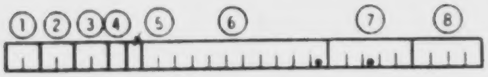
① WATER RATE, $/gal
② ELECTRIC RATE, $/kWh
③ STEAM RATE, $/1000 lb
④ FUEL RATE, $/gal
⑤ DIRECT LABOR, $/h
⑥ SUPERVISION LABOR, $/h
⑦ SOLID WASTE DISPOSAL RATE, $/ton
⑧ PAYROLL OVERHEAD, %
⑨ PLANT OVERHEAT, %
⑩ CAPITAL RECOVERY, %
⑪ ADMINISTRATION OVERHEAD, %
⑫ PROPERTY TAXES AND INSURANCE OVERHEAD, %
⑬ COST BASIS, e.g., 2nd QUARTER, 1979 = 2Q79
⑭ INFLATION FACTOR, e.g., 7% = 1.07

Figure 4. Card formats for Datasets 4, 5, and 6.

```
                        COKE OVEN OPTIMIZATION


     OBJECTIVE COST CALCULATION, NO OPTIMIZATION     75.1 % OVERALL EFFICIENCY  POLLUTANT: BAP     BASE YEAR 1979
     BASELINE: COST ADJUSTED FOR EXISTING CONTROLS


                                         CONTROLLED EMISSIONS                                                     CONTROLLED COST
                                   (LBS/TON COAL)               (TONS/YEAR)                                      (MILLION DOLLARS)

       SOURCE                TSP    BSO    BAP    BEN    TSP     BSO    BAP    BEN    CONTROL SCHEME           CAPITAL  ANNUALIZED
 LARRY CAR CHARGING         * .01  .0110  .0000  .0050     496    545     0   248 NEW CAR, STEAM, BOOT       303.6      164.7
 COKE PUSHING               *2.00  .0800  .0000  .0060  109463   4378     2   328 UNCONTROLLED                  .0         .0
 QUENCHING - CLEAN WATER    *1.70  .0017  .0001  .0000   41049     41     3     0 UNCONTROLLED                  .0         .0
 DOORS                      * .16  .2000  .0012  .0080    8757  10946    65   437 CLEANING & MAINT.             .0      173.8
 TOPSIDE                    * .02  .0250  .0001  .0005    1094   1368     5    27 LUTING & CLEANING             .0       57.2
 COMBUSTION STACK - OLD     *1.30  .0060  .0001  .0000   48840    225     2     0 UNCONTROLLED                  .0         .0
 COKE HANDLING              *1.00  .0000  .0000  .0000   54731      0     0     0 UNCONTROLLED                  .0         .0
 COAL PREHEATER             *7.05 1.0500  .0004  .0140   35925   5350     1    71 UNCONTROLLED                  .0         .0
 COAL PREPARATION           * .50  .0000  .0000  .0000   27365      0     0     0 UNCONTROLLED                  .0         .0
 COAL STORAGE YARD          * .15  .0000  .0000  .0000    8209      0     0     0 UNCONTROLLED                  .0         .0
 PIPELINE CHARGING          * .02  .0190  .0000  .0080      49     59     0    24 UNCONTROLLED                  .0         .0
 REDLER CHARGING            * .01  .0060  .0000  .0049      13      7     0     6 UNCONTROLLED                  .0         .0
 HOT LARRY CAR CHARGING     * .02  .0190  .0000  .0080      10     12     0     5 UNCONTROLLED                  .0         .0
 BY-PRODUCTS PLANT          * .00  .0600  .0000  .0400       0   3283     0  2189 MAINTENANCE                   .0       17.4
 COMBUSTION STACK - NEW     * .13  .0006  .0000  .0000    2231     10     0     0 UNCONTROLLED                  .0         .0
 QUENCHING - DIRTY WATER    * .48  .0016  .0001  .0001   14680     48     1     1 CLEAN WATER & BAFFLES       278.1      168.1


  TOTAL UNC.                  9.3  2.235   .006   .686  508238 122349   337 37577
  EXISTING CONTROL                                       388402  76172   254 17656                             297.5      197.1
  EXISTING EFFICIENCY                                      23.6   37.7  24.6  53.0
  BASELINE CONTROL                                       508237 122348   337 37577                                .0         .0
  BASELINE EFFICIENCY                                        .0     .0    .0    .0
  TOTAL CONTROLLED                                       352920  26278    84  3341                             581.7      581.2
  PERCENT CONTROLLED                                       30.6   78.5  75.1  91.1

             EXISTING                                          NEW
      TOTAL BATTERIES 216    TOTAL OVENS 12221         TOTAL BATTERIES   0   TOTAL OVENS     0

      TOTAL CAPACITY  109494267  TONS COAL             TOTAL CAPACITY        0  TONS COAL

                       76623000  TONS COKE                                   0  TONS COKE

      * NOT IN OPTIMIZATION
```

Figure 5. Sample output report of coke oven optimization model.

CONTROL CARD 1



① MONTH OF RUN

② DAY OF RUN

③ YEAR OF RUN

④ MODE: 1=DETERMINISTIC;
2=MINIMUM ANNUALIZED COST, RESTRICT EMISSIONS
3=MINIMUM EMISSIONS, RESTRICT ANNUALIZED COST
4=MINIMUM CAPITAL COST, RESTRICT EMISSIONS
5=MINIMUM EMISSIONS, RESTRICT CAPITAL COST

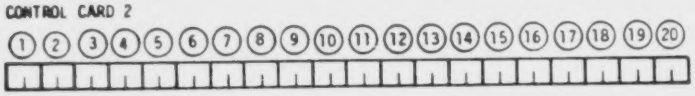
⑤ POLLUTANT OPTIMIZED

⑥ TOTAL DOLLAR RESTRICTION (FOR MODE 3)

⑦ TOTAL EMISSION RESTRICTION, PERCENT EFFICIENCY (FOR MODE 2)

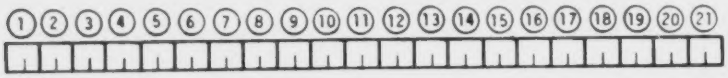
⑧ BASE YEAR OF DATA

CONTROL CARD 2



① THROUGH ⑳ FIXED CONTROL OPTION FOR EMISSION SOURCES 1 THROUGH 20

CONTROL CARD 3



① BASELINE CODE

② THROUGH ㉑ BASELINE CONTROL OPTION FOR SOURCES 1 THROUGH 20 RESPECTIVELY

Figure 6. Format for the control cards.

In Mode 2, the optimization routine is called into use. The user first specifies the sources that are to be fixed at a control level (i.e., as in Mode 1); the remaining sources will be optimized. A total control level expressed as percent efficiency for a given pollutant is specified and the lowest cost (either capital or annualized) combination that will meet that level is calculated. If some sources are specified to be uncontrolled and not included in the optimization, the user must take these emissions into account by lowering the total control efficiency. Otherwise, an infeasible solution can result because the remaining controlled sources may not meet the total allowable level. The output is similar to that in Figure 5. A symbol (#) appears by each source that was fixed, and these do not enter into the optimization.

In both modes the number two control card can be used to set a control level for any given source equal to uncontrolled, in which case the cost is zero. In effect, this enables certain sources to be removed from the optimization analysis.

The base year specified on Control Card 1 is merely a reference date to be printed on the output report. If, for example, the run is a projection for 1985 and projected new batteries have been added to the battery data base, the base year will be 1985. Presently, no new batteries are included in the battery data base and the base year is 1979.

Mode 3 is the opposite of Mode 2. A cost limitation (either capital or annualized) is entered, and the optimization program determines the lowest emission rate for the specified pollutant. It is probably necessary to run Mode 1 and Mode 2 before running Mode 3 to have some idea of what constitutes a reasonable total cost.

The comments portion of the printout will contain messages indicating unreasonable conditions, input errors, or solutions beyond the bounds of the program. For example, if the emission restriction (Mode 2) cannot be achieved by the control systems available to the program, the printout will give a message to that effect.

Control Card 3 controls the baseline used for most calculations. The baseline codes are as follows:

Code	Baseline
1	Uncontrolled; i.e., all costs are calculated with no regard to existing controls or existing State Implementation Plan (SIP) requirements.
2	Existing control; costs are adjusted by not counting the cost of controls already installed.
3	SIP; i.e., costs are adjusted by not counting the cost of controls required by SIP whether they are actually installed or not. No account is taken for existing controls which exceed SIP requirements.
4	Average SIP; this option is the same as Option 3, but for convenience of data preparation only one SIP definition is used and applied to every plant; whereas as in Option 3 the specific SIP must be entered on each battery card depending on the state in which the battery is located.
5	This is a combination of 2 and 3. The costs are adjusted by not counting the cost of controls already installed or the cost of controls required by SIP whichever is greater.
6	Average SIP and existing; this option is the same as Option 5 but only one SIP definition is used and applied to every plant.

Note that no entries are required beyond field one for the baseline Options 1 and 2 because no distinction is made between sources in these options. For baseline Options 3 and 5, the control option codes corresponding to SIP must be entered on the coke oven battery data cards rather than using Control Card 3.

Currently the model does not attempt to account for costs of tear-out. If, for example, the optimum alternative differs from that already installed in a given plant, no tear-out costs are included. Nor does the model address incremental costs for moving from one control scheme to a higher-cost scheme. If, for example, existing control is a shed and scrubber and the optimum alternative is a shed and ESP, the full cost of the optimum alternative is included rather than just the cost of the ESP.

In Figure 5, line 1 displays the total weighted uncontrolled emissions expressed in lbs/ton of coal and total tons. Lines 2 and 3 display the total tons of emissions and percent efficiency respectively for existing controls. Lines 4 and 5 display the total tons of emissions and percent efficiency respectively for the baseline controls which are in the optimum solution. Lines 6 and 7 display the total tons of emissions and percent efficiency for the optimum solution. The costs shown on line 2 represent the value of existing controls. The costs shown on line 4 represent the cost of the controls contained in the optimum solution which are already installed or assumed to be installed as designated by the baseline.

The costs shown on line 6 represent the cost of the controls in the optimum solution which exceed the baseline control level. The sum of these two lines therefore represents the total value of the controls in the solution.

SECTION 3

EMISSION FACTORS

For the 16 emission sources identified, emission factors were developed for each of the four pollutants: particulates, BSO, BaP, and benzene. To the extent possible, results from emission tests were used to establish these emission factors. When explicit data were unavailable, an attempt was made to derive an emission rate from other available information and assumptions. If an emission factor could not be developed by either of these approaches, an engineering estimate was made as accurately as possible. All the matrix numbers had to be provided (even if estimated) so that initial runs of the model could be completed. As new data become available, the values in the matrix (Table 1) can be updated to reflect more accurately the nature of emissions from byproduct coke ovens. If estimates have a broad confidence range, model runs can be made for various values to examine sensitivity.

Data were obtained from PEDCo's files, EPA reports, articles in various journals, and emission test reports. A literature search provided considerable information on coke oven emission sources and methods of reducing emissions; however, little actual test data or emission factors were available in comparison with the total number of potential emission sources. When actual numerical values were reported, they were used. The level of precision used in reported results was retained herein, but this does not imply that the value is precise when used as a general emission factor for all batteries. This is not surprising because it is difficult to sample these emission sources, most of which are fugitive in nature. Nevertheless, the literature did provide considerable information on control techniques and what could be expected from them.

Because most emissions from the 16 sources are fugitive in nature, they do not lend themselves readily to Method 5 sampling techniques. Two commonly used techniques are single-point sampling with a Method 5 sampling train and sampling a fugitive plume with a High-Vol sampler. Sampling is sometimes attempted at isokinetic conditions, even though it often is difficult to achieve. Generally sample results are merely corrected to reflect isokinetic sampling. These methodologies appear to yield as reliable data as can be expected.

Using test data to develop emission factors requires several assumptions. The first is that the results of the test are representative of the emissions found at the entire battery (e.g., charging emissions do not differ significantly from one oven to another if the same sampling procedures are followed). In the case of door emission tests, one notable exception would be if test results were obtained on only one door; the fact that the one door tested was leaking does not indicate that all the doors leak. Another exception would be the sampling results from a single green push; one push does not necessarily represent all the coke pushes of that battery.

The second assumption is that the emissions from the battery tested are representative of the industry as a whole. Although it would be ideal to have test results from various plants for confirmation, it must be assumed that the values from the test used are the best currently available and are representative of battery emissions within the entire industry.

Several problems are unresolved. One is the matter of equivalency of two different sampling methodologies. Although some difference can be expected between the results of the Method 5 train and the Hi-Vol method (depending on the parameters of the emission stream sampled), they are similar enough to be considered equivalent methods. Another problem is the definition of TSP. Generally, a reference to a particulate catch means the front half of a Method 5 train (or its equivalent). Total suspended particulate (or TSP), however, implies both the front half and back half of a Method 5 train particulate catch (or the equivalent). Because the definition of particulate matter is generally a function of temperature, emission factors derived on the basis of a front-half catch and those derived from both a front- and back-half catch would differ significantly. Thus the definition would tend to affect the predicted control efficiencies, particularly when discussing TSP. It is likely that many of the control devices on the optional control systems would not "see" the particulate captured in the back half of the sampling train because it would be gaseous in form as it passed through the control device and would condense some time later. Still another problem concerns the different methods used to test the various organic species to determine emission rates. Nevertheless, the variability between samples appears to have a greater effect than the differences in sensitivities and biases of the analytical methods because the different analytical methods are believed to yield essentially the same results.

The nature and magnitude of the biases on test results for each of the identified emission sources are discussed. Also discussed are the specific assumptions and references used to arrive at each emission factor. The general assumptions and comments just covered apply to nearly all the emission sources. For ease in predicting control efficiencies, particulate emission factors are given either as the front-half or equivalent value.

3.1 SOURCE 1--LARRY CAR CHARGING (WET COAL)

Particulates

A baseline of emissions must be established when referring to larry car charging. For the purposes of discussion, "uncontrolled" is assumed to mean that a minimal amount of control is applied during charging and minimal effort is expended to reduce emissions from wet coal charging. (This generally reflects the situation in the industry about 10 years ago.) On this premise, an uncontrolled emission factor of 1 lb particulate/ton of coal charged has been estimated by EPA in the draft Standard Support and Environmental Impact Statement (SSEIS) for charging.[1] It is not known whether this number represents what could be expected to be captured by the total Method 5 train or just the front-half particulate catch. If this factor represents only the front half, actual total uncontrolled particulate is likely to be 1.96 lb/ton coal because it is assumed that the ratio of particles collected in the front half and back half of a train are about equal. This was the case in the testing of an experimental larry car during a joint project between the American Iron and Steel Institute (AISI) and the EPA. The back half proved to be approximately 0.96 of the mass of the front half.[2,3]

The results of four tests revealed a controlled emission rate of 0.017 lb/ton coal (front half) for stage charging. It should be noted that these four tests were conducted anisokinetically, then corrected to reflect isokinetic conditions. A total particulate factor, calculated on the basis of the front-half catch, is 0.033 lb/ton coal.[2,3]

A standard Wilputte larry car tested as part of the AISI/EPA program was found to have an emission level of 0.14 lb/ton coal (front-half, 10-test average) when tested by the same method as the experimental larry car. The test values could be in error as much as an order of magnitude, but less error is expected because of the sample size of ten. These latter tests were used as a guide in assigning a control efficiency for conventional stage charging.

Benzene Soluble Organics

The AISI/EPA particulate test revealed that BSO comprised 57 percent of the front-half catch and 60 percent of the back-half, and it can generally be assumed that BSO comprises 55 to 60 percent of the total particulate catch without significant chance of error.[1,2,4] With the use of the BSO/particulate ratios above, the calculated emission factors from the AISI/EPA test are as follows:

Uncontrolled	1.1 lb/ton coal
AISI/EPA larry car	0.019 lb/ton coal

Benzo-a-Pyrene

A significant variation in the levels of BaP was detected in the samples tested. Although the number of samples tested was not statistically large enough to derive a highly reliable emission factor, the AISI samples in which BaP was observed indicated an "average" of 2×10^{-5} lb/ton coal.[1,2] An emission factor for BaP of 0.002 lb/ton coal has been calculated on the basis of ambient data and the ratio of BaP and BSO.[1,4,5] This latter value is considered more reliable because of the large sample size and is used in the model.

Benzene

No explicit data on the magnitude of benzene emissions were found in the references noted above; however, an emission factor was calculated on the basis of the results of two tests of coke-side shed emissions and a test on coke-oven door emissions.[6-9] These tests indicate that benzene emissions are equivalent to 25 to 50 percent of the front-half particulate emission rate. (This is not to say benzene is captured in the front-half.) Assuming an emission rate for benzene equivalent to 50 percent of the front-half catch, the following emission factors are calculated:

Uncontrolled	0.5 lb/ton coal
AISI/EPA larry car	0.008 lb/ton coal

These rates are highly variable for door emissions, however, and using these estimates to derive an emission factor for charging emissions provides a low-confidence estimate.

3.2 SOURCE 2--COKE PUSHING OPERATIONS

Particulates

Several data sources were available to use in the calculation of an emission factor for coke pushing operations.[6,7,8,10,11] The magnitude of pushing emissions varies, depending on test methodology and "greenness" of the push. The sources used were a report on tests using Hi-Vol samplers suspended in the plume and one on sampling isokinetically.[12-14] Results from tests using a Method 5 sampling train or sampling the stack of a cokeside shed appeared somewhat low and biased (a certain amount of dilution could bias the results on the low side). The two coke pushing operations tested were in close agreement. One of the batteries used an enclosed push car with hooding to capture the particulate.[13-15] The enclosed car was controlled by a scrubber, and a standard Method 5 sampling train was used to sample the scrubber inlet and outlet. A Hi-Vol sampler was placed above the hood to capture the fugitive emissions. The total emission rate of particulate was estimated by combining the results of the Hi-Vol sampler and the scrubber inlet.

The emission rate from pushes that were moderately green averaged approximately 2.0 lb particulate/ton coal. Because little condensible matter was found in proportion to the particulate captured (i.e., back-half vs. front-half), a separate emission factor for a front-half and back-half TSP need not be calculated. For clean pushes an emission factor of 0.7 lb particulate/ton coal appears appropriate.

The significance of the clean push emission factor involves two separate items. First, the use of dry coal charging appears to provide uniform coking while reducing coking time.[16] When running this optimization model it may be appropriate for the coke pushing emission factor to be selected on the basis of whether wet coal or dry coal methods are employed. Second, an often discussed alternative or control option is to increase the average coking time and establish some minimum coking time before pushing takes place. Such an option might reduce emissions in cases where battery operators otherwise would cut short the coking time, but indications are that the greenness of the push is more closely related to the oven characteristics and heating integrity than to coking time.[12] Although further study is needed, it is conceivable that some ovens in need of maintenance could not thoroughly "coke-out" the coal charge regardless of coking time. The greenness of the push after some specified minimum coking time might therefore be used as an indicator that an oven needs maintenance.

Benzene Soluble Organics

An emission factor for BSO as condensibles in the coke pushing operations was based on a test of the hooded coke car used in the Ford/Koppers demonstration project.[13,14] The emission rate was determined to be 0.08 lb BSO/ton coal for pushes that were moderately green, and a BSO emission factor of 0.03 lb BSO/ton coal was determined for clean pushes. These rates are based on the assumption that most of the condensible material captured is BSO. Although tests of coke-side sheds indicate that the amount of BSO generated is somewhat higher than these rates, it is believed that other factors (such as door leaks) biased the results.[4,6,7,8] Results of another test for coke pushing emissions, which will be available in several months, may confirm the stated emission factors.

Benzo-a-Pyrene

Emissions of BaP were detected by sampling with cyclohexane and analyzing by GC/MS. An emission rate of 4×10^{-5} lb BaP/ton coal was established.[13,14] It should be noted that the emissions of BaP were not reduced by passage through the venturi scrubber used at the plant, even though the emission level is very low. Although door leaks tend to interfere with the results, tests of the coke-side shed confirm the relatively low level of emissions.[4,6,7,8]

Benzene

The tests of the Ford/Koppers scrubber-controlled quench car showed a small amount of benzene released during coke pushing operations. The average of six tests was 0.008 lb C_6H_6/ton coal (actually benzene and homologues). The actual rate of benzene only is expected to be in the range of 0.006 to 0.008 lb/ton coal. For clean pushes, benzene emissions could be as low as 0.0005 lb/ton, but they are expected to average 0.001 lb/ton coal. These factors are based on tests of the Ford/Koppers system.[13,14]

3.3 SOURCE 3--QUENCH TOWERS WITH CLEAN H_2O; SOURCE 16--WITHOUT CLEAN H_2O

Particulates

Considerable data have become available on the magnitude and nature of coke quench tower emissions.[17-21] Besides the interest in the various types of control options, considerable interest has developed in quenching with clean versus dirty water. Emission factors for quenching with both clean and dirty water are discussed.

The development of an emission factor for particulate from quench towers is based primarily on the work of Edlund et al.,[18,19] and on a data comparison from a recent report by Midwest Research Institute (MRI).[20] The results of the various tests vary widely; however, a data comparison was made primarily between Method 5 tests and Hi-Vol sampling techniques. It is difficult to maintain isokinetic sampling rates in the gas stream because the moisture content varies widely, but isokinetic sampling may be maintained "over the average." The difference in quench tower designs and other variables make it difficult to quantify the bias. Uncontrolled emissions from quench towers refer to the use of natural draft towers without baffles or other control devices to capture the emissions from wet quenching. The following particulate emission factors (to be used in the model) are based on Edlund et al.:[18,19] 1.7 lb particulate/ton coal (clean H_2O), 3.2 lb particulate/ton coal (dirty H_2O). These numbers are slightly higher than the averages from MRI, but they are well documented and fall well within the range of variation observed for the various tests. There appears to be no direct correlation between particulate emissions from quenching and the greenness of a push.

Benzene Soluble Organics

Many of the tests performed were also for the purpose of quantifying emissions of organic materials. Again, variations were similar to those observed for particulate emissions. For example, some test results from "clean" water quenches showed higher emission rates than results from "dirty" water quenches.[20] The emission factors shown below, however, are based on recent test[17,21] results from a quench tower where the concentration of BSO in the gas stream was found to be about 1000 times less than the concentration of particulate matter during clean water quenches. Furthermore, dirty water quenches showed a concentration of BSO four times higher than that found in clean water quenches.[17,21] Based on these ratios, the emission factors for BSO to be used in the model are:

1.7×10^{-3} lb BSO/ton coal (clean H_2O)
6.4×10^{-3} lb BSO/ton coal (dirty H_2O)

Benzo-a-Pyrene

Several tests made of the emissions of BaP showed some variations, but the absolute variation was small. The appearance of these variations may be due to the low levels of BaP present, which approach the detection limits of the sampling methodology. On the other hand, the data appeared to be consistent with the particulate data because dirty water quenches had about twice the level of pollutant emission as clean water quenches.[17,21] The following emission factors were indicated:

1.4×10^{-4} lb BaP/ton coal (clean H_2O)
3.1×10^{-4} lb BaP/ton coal (dirty H_2O)

Emissions of BaP, which are not found in every sample, appear to be related somewhat to the greenness of the push.

Benzene

Data are limited regarding benzene emissions. Only two grab samples are available, and the data do not explicitly indicate whether these samples were taken during clean or dirty water quenches.[17] Although the reliability of these values is extremely poor, they are used with the assumption that a higher level of benzene will be found in dirty water quenches:

3×10^{-5} lb/ton coal (clean H_2O)
2.6×10^{-4} lb/ton coal (dirty H_2O)

3.4 SOURCE 4--DOOR EMISSIONS

Particulates

Considerable data are available on emissions from doors during the coking cycle.[6-10,22,23] It can normally be assumed that any door emissions that occur will be greatest during and immediately after oven charging.[5,9] One test indicated that most emissions occur within the first 8 hours of the coking cycle. In a discussion of door emissions, it is difficult to define "uncontrolled" emissions. Two methods might be used to determine uncontrolled emissions. First, uncontrolled door emissions may be defined as emissions occurring because of failure to clean the oven doors thoroughly after each cycle. Such failure results in improperly sealed doors. Uncontrolled emissions might also result from failure to immediately remove damaged and warped doors from service for repairs at the end of a cycle. A second definition of uncontrolled emissions might be based on the number of doors leaking (e.g., no more than 40%). Thus, "uncontrolled" is not necessarily a measure of effort, but rather of results. A series of two tests were performed using an enclosure hood around the door and a Hi-Vol sampler. An emission rate of 0.025 to 0.04 lb/ton coal can be calculated from these data,[9] but this value seems low in view of available data from tests of coke-side sheds and door emission sheds with prototype gas cleaning equipment.[23] These latter data produced an uncontrolled emission factor of 0.4 lb/ton coal, which will be used in the model. This factor is based on the assumption that emissions from both sides of the battery are essentially the same and that approximately 40 percent of the doors leak when "uncontrolled."

Benzene Soluble Organics

A considerable portion of the door emissions is BSO; the BSO may actually exceed the front-half particulate emissions. The data from most of the tests indicate a factor of 0.25 lb BSO/ton coal may be appropriate for emissions from the doors on one side of a battery.[4,9] This value is supported both by tests on a single door and by tests of continuous background emissions in a coke-side shed.[6-8] The values obtained from the shed are more significant in that they consider the average of all leaks from one side of the battery. Again, it is assumed that the emission rates from both sides of the battery are equal, resulting in a total emission rate of 0.5 lb BSO/ton coal.

Benzo-a-Pyrene

Based on most of the data available from stack tests and comments from EPA, an BaP emission factor of 0.003 lb BaP/ton coal appears appropriate, although some data indicate a lower level of emissions is possible.[1,4,6-9] If 40 percent of the coke battery doors are leaking, it is believed that the emissions from doors would be equal to or greater than that for "uncontrolled" larry car charging.

Benzene

Emissions of benzene can represent a significant portion of the condensible particulate matter during the initial portion of the coking cycle, but these emissions appear to decrease rapidly over the first 2 to 3 hours.[9] Averaged over the entire coking cycle and from several ovens, benzene emissions appear large at first, then decrease considerably in magnitude.[9] The results from both an individual door test and tests of a coke-side shed indicate an emission factor of 0.01 lb C_6H_6/ton coal for one side of the battery.[6-9] For both sides (assuming both emit equally) the emission factor is 0.02 lb C_6H_6/ton coal.

3.5 SOURCE 5--TOPSIDE LEAKS

Although no test data are available for reliable quantification of topside emissions, it is likely that they are similar in composition to door emissions. It is also likely that such emissions are less than half those from door leaks.[1,4] The rationale for this assumption is that the area through which topside emissions may escape is roughly half that of the doors, oven pressure is generally lower, and the emissions are more easily controlled (e.g., by luting or replacement of warped lids). Emissions occur primarily from charging lids and standpipe caps.[1,4] The following emission factors will be used for the model:

Particulate	0.2 lb/ton coal
BSO	0.25 lb/ton coal
BaP	0.001 lb/ton coal
Benzene	0.005 lb/ton coal

These uncontrolled emission factors are based on the assumption that a minimal amount of manpower is devoted to topside maintenance.

3.6 SOURCE 6--OLD COMBUSTION STACK; SOURCE 15--NEW COMBUSTION STACK

Particulates

Although data are available for calculating emission factors for combustion stacks, they are currently considered confidential and cannot be used in this study. Enough information was provided to estimate the level of emissions, however. When use of the data is permitted, they should be incorporated into the matrix of emission factors.

An average particulate emission factor for all combustion stacks is estimated to be 0.7 lb/ton coal.[5] The range of values is wide, however, with old battery stacks showing higher emissions because of oven cracks and subsequent leakage into the flues. Nevertheless, the values are expected to be well within the range of 1.3 lb/ton coal for the old stack and 0.13 lb/ton coal for the new stack. The values are known to be about an order of magnitude apart.

Benzene Soluble Organics

Emissions of BSO are expected to be small from combustion stacks: 0.006 lb/ton coal from old stacks, and 0.0006 lb/ton coal from new stacks.

Benzo-a-Pyrene, Benzene

Emissions of BaP range from 6×10^{-5} lb/ton coal from old stacks to 6×10^{-6} lb/ton coal from new stacks. Very little benzene is believed to be emitted because it is probably combusted.[5] Therefore, benzene emissions are considered to be zero.

3.7 SOURCE 7--COKE HANDLING

Particulates

No explicit data were found on which to quantify emissions from coke handling, but it is assumed that the coke is cooled sufficiently to prevent hydrocarbon emissions. Further, it is expected that larger particulate matter from sizing and screening operations would contribute greatly to the total particulate mass.[24] Therefore, an emission factor of 1.0 lb/ton coal has been estimated. This value is twice that found for coal preparation.

3.8 SOURCE 8--COAL PREHEAT

Particulates

Data from several tests of coal preheating systems are used to indicate the level of emissions to be expected from the preheater.[25,26] More data are needed to improve the data base and should be added as they become available.

The particulate emission factor is based on the results of two series of emissions tests in which production rates and drying temperatures varied.[25] Particulate emissions appear to relate primarily to the rate of coal drying, and there is a slight correlation between emissions and gas temperatures. An average uncontrolled emission rate was developed over six test runs with the various production/temperature combinations and was determined to be 7.05 lb particulate/ton coal.[25] The relationship between production rate and emissions/ton coal appears to be inversely proportional. "Uncontrolled emissions" refers to the use of no control device after initial separation of the preheated coal from the gas stream.

Benzene Soluble Organics

The level of organic emissions (taken as BSO) was also tested during the particulate tests and average emissions were determined to be 1.05 lb/ton coal for six tests.[25] More recent data indicate a slightly higher emission rate, but this factor will be used until more information becomes available.[26] Although not enough data are available to define accurately the relationship between gas temperature and the rate of organic emissions, the emission rate appears to increase exponentially with higher production rates. Organic emissions also appear to increase with gas temperature.

Benzo-a-Pyrene

Recent data on BaP emissions indicate that emissions from the preheater scrubber outlet are approximately 2.0×10^{-4} lb

BaP/ton coal.[26] Based on an assumed scrubber efficiency of 50 percent for BaP, the uncontrolled emission rate would be 3.9 x 10^{-4} lb BaP/ton coal. Although the absolute variation of the emission rates tends to be small, the percentage variation is quite high.

Benzene

Data concerning benzene emissions are confusing at best.[26] Recent data indicate benzene emissions to be higher at the scrubber outlet than at the inlet, which would indicate a "negative" efficiency for benzene scrubbing, but no other source for benzene has been found that would clarify this. The outlet values will be used to determine an emission factor for the model. These values should be considered of low reliability, however, until the results are explained. One possible explanation is that the data sets might be reversed. Because insufficient data were provided to calculate a benzene emission factor directly, the known ratio between benzene and BSO had to be used. Based on the ratio between benzene and BSO hydrocarbons from this test (factor = 0.0130 x BSO), benzene emissions are estimated to be 0.014 lb C_6H_6/ton coal.

3.9 SOURCE 9--COAL PREPARATION

Particulates

Coal preparation is generally defined as the crushing, screening, and sizing of coal prior to charging of the ovens. Included are the emissions from handling and material transfer points. Coal dust is the predominant particulate emission. Normally no hydrocarbons are emitted because insufficient heat is supplied to cause any carbonization of the coal. It is assumed that the coal has been washed and separated from the burden material at the coal mine prior to its transport to the coke battery. Two sources indicate that with minimal controls (i.e.

hooding, water sprays), the expected particulate level is approximately 0.5 lb particulate/ton coal. This includes all transfer and crushing points.[27,28] Uncontrolled emissions have the potential to be as high as 10 lb particulate/ton coal.

3.10 SOURCE 10--COAL STORAGE

Particulates

The only pollutant of concern from this source is particulate because it is assumed that the other pollutants either do not occur or are below detectable levels. The amount of particulate emissions from coal storage piles is usually a function of the size and shape of the storage pile, the wind speed, and the amount of material movement on the pile.[29] Thus a site-specific value would need to be assigned for the storage pile at each plant. PEDCo has performed several surveys on emissions from storage piles.[29,30] Based on the assumption that the storage pile will be relatively inactive and that wind erosion is the primary cause of fugitive emissions, the emission factor would be 0.10 to 0.15 lb/ton coal. If loading onto the storage pile, traffic around the pile, and loadout of material are considered, the emission factor would be in the range of 0.4 to 0.5 lb/ton coal. The former value will be used in the model. If the total activity on or around the piles is applicable, the higher value can be used.

3.11 SOURCE 11--PIPELINE CHARGING (PREHEATED DRY COAL)

Particulates

Theoretically, emissions from pipeline charging could be near zero. In most cases, however, theoretical and actual values differ significantly at the batteries observed to date. In most pipeline charging operations, both operation and maintenance practices and engineering design factors have contributed to the level of emissions that have been observed.[16]

No formal tests have been made of emissions caused by pipeline charging. The charging hole lids and standpipe elbow covers are the major emission points. (Door leaks can also be a significant source of pollutants; these are discussed under Source 4.) The emission factors presented below are arrived at by relating a mass/time emission factor to visible emissions, using a mass/time constant of 0.0015 lb particulate/second of observed emissions. This factor is based on observation of the AISI/EPA larry car emissions.[2,3,16] Based on this factor, an average of approximately 0.55 lb/charge was observed at the "worst case" battery. It is assumed here that the characteristics of charging emissions are the same as those observed for the AISI/EPA larry car charging. If the quantity of coal charged to the oven is assumed to be equivalent to 35 tons of wet coal, the emission factor is calculated to be 0.016 lb/ton coal.[16] This value would be equivalent to that captured by the front half of a Method 5 sampling train. A total particulate emission factor of 0.031 lb/ton coal can be developed for a front and back half if it is assumed that characteristics are the same as those for the emissions of the AISI/EPA larry car charging. The assumptions used for calculating emission factors for dry coal charging are broad, and the results derived must be considered tenuous. The computations show that emission factors for pipeline charging and the AISI/EPA larry car charging are comparable. Informal observations also show that pushes from batteries using dry coal tend to be cleaner (i.e., the coal is more completely "coked") than those from batteries using wet coal. This factor has not been quantified in the model.

Benzene Soluble Organics

If it is assumed that emission characteristics are similar for BSO from both wet and dry coal charging and that BSO comprises 60 percent of the total particulate emissions, the calculated emission factor would be 0.019 lb BSO/ton coal. The assumed value of 60 percent is slightly higher than that observed at the AISI/EPA test; however, the preheated coal may produce more volatile organic compounds during charging because of its higher temperature.

Benzo-a-Pyrene

Because both the emission factors and the assumed emission characteristics are similar to those of the AISI/EPA larry car, the BaP/BSO ratio for wet coal charging is used to derive an emission factor of 3.5×10^{-5} lb BaP/ton coal.

Benzene

For similar reasons, the benzene emission factor to be used in the model is 0.008 lb C_6H_6/ton coal.

3.12 SOURCE 12--REDLER CONVEYOR (PREHEATED COAL) CHARGING

No formal emission tests have been performed on the Redler conveyor system. An emission factor has been developed, however, on the basis of several visible emission observations.[16] Based on seconds of observed emissions, the emission factor is estimated to be 0.35 lb/ton charge. Assuming an equivalent 35 tons of wet coal/charge, the emission factor is 0.01 lb/ton coal.[16]

Particulate emissions were observed primarily from the charging ports and from the conveyor/chute junction. Emissions from the charging ports are not expected to differ significantly from those produced by the AISI/EPA larry car.[16] Emissions from the conveyor/chute junction, however, appear to be mostly relatively large coal particles which could increase the weight of total particulate emissions.[16] These emissions should not increase the emission factor above 0.03 lb/ton coal.

An emission factor based on total particulate emissions (front- and back-half) is expected to range from 0.0148 to 0.0168 lb/ton coal, primarily because of condensible emissions from the charging ports. (This is assuming that ∿1/2 of the total emissions are from the charging ports, that the back-half emissions would be 96 percent of the mass of the front-half, and that the total of any other emission sources is added.)

Benzene Soluble Organics

Emissions of BSO are expected to be less than those from pipeline and larry-car charging because the ratio of BSO to total front-half and back-half particulate is lower. The change in this ratio is due to the relative short periods of visible emissions that have been observed from the charging ports where the BSO is assumed to originate. Charging port emissions represent 0.0098 lb/ton (estimated) of particulate; if 60 percent of the particulate fraction is assumed to be due to BSO, emissions are calculated to be 0.006 lb BSO/ton coal.

Benzo-a-Pyrene

Because of the small quantity of BSO emitted, emissions of BaP are expected to be less than half that expected for the worst case for wet-coal larry car charging, or 0.0005 lb BaP/ton coal; and they could average as low as 1.1 x 10^{-5} lb BaP/ton coal. The latter value will be used in the model because it is believed to be more representative of actual emissions.[5]

Benzene

Emissions of benzene are difficult to quantify. Based on the assumption that benzene emissions originate from the charging port and that the emission factor is 25 percent of that for total particulate emissions from the charging port (0.0098), the emission factor becomes 0.0025 lb C_6H_6/ton coal. At 50 percent of the total particulate from the charging port, the emission factor becomes 0.0049 lb C_6H_6/ton coal. This higher value will be used in the model.

The preceeding emission factors are only estimates; there are no test data to substantiate them. Dry coal charging should improve the level of pushing emissions because of the greater number of "clean" pushes resulting from more complete coking; it should also provide the potential for lower levels of charging emissions.

3.13 SOURCE 13--HOT-LARRY-CAR CHARGING (PREHEATED DRY COAL)

Although no data are available on which to base emission factors for any of the four pollutants, these emissions are not expected to be significantly higher than those from wet-coal charging. Because the equipment will be new, the hot larry car should perform as well or better than the AISI/EPA larry car.[16] Therefore, the following emission factors are to be used:

0.017 lb particulate/ton coal
0.033 lb total particulate/ton coal
0.019 lb BSO/ton coal
3.5×10^{-5} lb BaP/ton coal
0.008 lb C_6H_6/ton coal

The value for total particulate emissions is not used in the model, but it is shown for general information.

3.14 SOURCE 14--BYPRODUCT RECOVERY PLANTS

It is difficult to quantify the emissions from coke-oven byproduct-recovery plants. The main difficulties are the numerous fugitive sources and the significant differences in the type of byproduct recovery practiced from plant to plant. The approach taken to quantification of emissions was to select a plant that appeared to be representative of a majority of the byproduct recovery plants. Because not all sources of emissions have been tested and reliable emission data are not readily available, the estimates presented here are rough, and represent only the summation of estimates for various areas in a typical byproduct plant.[31] Front-half Method 5 particulate emissions are believed to be zero.

The primary pollutants appear to be organics, but no useful data are available except on benzene. During processing, the coke-oven gas is cooled to a sufficiently low temperature to condense the various hydrocarbons that make up the benzene soluble organics. Therefore only those with relatively high volatility should be emitted as fugitive emissions. Based on test data and estimates, benzene emission are calculated to be at least 0.2 lb/ton coal. It is possible some constituents of BSO (such as naphthalene) are emitted at very high levels and contribute at least 0.3 lb BSO/ton coal. This value will be used in the model until more specific data become available.[5,31] Although BaP levels are unknown, they should be relatively low because of the condensation effect mentioned above.[5,31] For the purposes of the model, BaP emissions will be considered zero.

REFERENCES FOR SECTION 3

1. Draft of Standards Support Environmental Impact Statement. Volume 1: Proposed National Emission Standards, Byproduct Coke Oven Wet-Coal Charging and Topside Leaks. Emission Standards and Engineering Division, U.S. EPA, Research Triangle Park, N.C. June 1978.

2. Coke Oven Charging Emission Control Test Program. Vol. 1. EPA-650/2-74-062. July 1974.

3. Coke Oven Charging Emission Control Test Program--Supplemental Observations. EPA-650/2-74-062A. September 1974.

4. Trenholm, A.R., and L.L. Beck. Assessment of Hazardous Organic Emissions from Slot Type Coke Oven Batteries. ESED, U.S. EPA, March 16, 1978.

5. Personal communication from A.R. Trenholm, ESED, U.S. EPA, March 21, 1979.

6. Source Testing of a Stationary Coke Side Enclosure. EPA-340/1-76-012. 1976.

7. Great Lakes Carbon Corporation. Study of Coke Side Coke-Oven Emissions. EPA-340/1-77-014A. Vol. 1: Source Testing of a Stationary Coke Side Enclosure. St. Louis, Missouri. 1977.

8. Great Lakes Carbon Corporation. Study of Coke Side Coke-Oven Emissions. EPA-340/1-77-014A. Vol. 2: Source Testing of a Stationary Coke Side Enclosure. St. Louis, Missouri.

9. Sampling and Analysis of Coke Oven Door Emissions. EPA-600/2-77-213. 1977.

10. Paley, L.R., and R.J. Powals. Assessment of the Fugitive Particulate Emissions Escaping from a Coke-Side Shed. (Date and Publication Date Unknown).

11. Paley, L.R., M. Antell, V.W. Hanson, and R.J. Powals. Were the Measured Emission Rates Representative of a Coke Battery's Typical Emissions? Presented at the Joint APCA/Source Evaluation Society Meeting, Dayton, Ohio, September 19, 1975.

12. Jacko, R.B., D.W. Neuerdorf, and J.R. Blandford. Purdue University, West Lafayette, Indiana 47907. Plume Parameter and Particulate Emissions from the Byproduct Coke Oven Pushing Operation. Presented at the 71st APCA Conference, Houston, Texas, June 25-30, 1978. APCA No. 78-9.4.

13. Emissions Testing and Evaluation of Ford/Koppers Coke Pushing Control System. Vol. 1: Final Report. EPA-600/2-77-187A. 1977.

14. Emissions Testing and Evaluation of Ford/Koppers Coke Pushing Control System. Vol. 2: Appendices. EPA-600/2-77-187B. 1977.

15. Roe, E.H., and J.D. Patton. Coke Oven Pushing Emission Control System. Journal of the Air Pollution Control Association, 25(4):379-382. April 1975.

16. PEDCO Environmental, Inc. Control of Emissions from Dry Coal Charging at Coke Oven Batteries. (Preliminary Draft). Prepared for U.S. EPA, IERL, OAQPS, Durham, N.C., under Contract No. 68-02-2603, Task 28. October 1978.

17. Dowling, M.P., J.D. Jeffry, and A.H. Laube. York Research Corporation, Stamford, Connecticut. Reduction of Quench Tower Emissions. Presented at the 71st APCA Conference, Houston, Texas, June 25-30, 1978. APCA No. 78-9.2.

18. Edlund, C., A.H. Laube, and J.D. Jeffry. U.S. EPA, Washington, D.C. Effects of Water Quality on Coke Quench Tower Particulate Emissions. Presented at the 70th APCA Conference, Toronto, Ontario, Canada, June 20-24, 1977. APCA No. 77-6.3.

19. Laube, A.H., J. Jeffry, and C. Edlund. Characterization of Pollutants Exiting Quench Towers. Presented at the 4th National Conference on Energy and the Environment, Cincinnati, Ohio, October 3-7, 1976. pp. 260-267.

20. Midwest Research Institute. Engineering Analysis of Emission Controls for Wet Quench Towers. Prepared for ESED, U.S. Environmental Protection Agency, Research Triangle Park, N.C., under Contract No. 68-02-2609, Task 7.

21. Rudolph, J.L., and C.E. Rechsteiner. Analysis of Samples from Coke Quench Tower Emissions. (Draft). Prepared by Arthur D. Little, Inc., for York Research Corporation. November 1978.

22. Study of Concepts for Minimizing Emissions from Coke-Oven Door Seals. EPA 650/2-75-064. 1975.

23. Barrett, R.E., and P.R. Webb. Effectiveness of a Wet Electrostatic Precipitator for Controlling POM Emissions from Coke Oven Door Leakage. Presented at the 71st Annual Meeting of the Air Pollution Control Association, Houston, Texas, June 25-30, 1978.

24. Air Pollution in the By-Product Coke Industry. Chapter II: Dust and Fume Generation in the Iron and Steel Industry. Russian Translation, MIR. 1977.

25. Betz Environmental Engineers. An Emission/Efficiency Evaluation of the A-5 Coke Oven Battery North Pre-Heat Bleed Venturi Scrubber System at the Aliquippa Works of the Jones and Laughlin Corporation. Pittsburgh, Pennsylvania, January 1977 and May 1977 (two tests).

26. York Research Corporation. Draft data from coal preheater tests at J&L Steel (Aliquippa Plant). EPA/IERL. July-August 1978.

27. Background Information for Standards of Performance: Coal Preparation Plants. Volume 1: Proposed Standards. EPA-450/2-74-021a. October 1974.

28. Inspection Manual for Enforcement of New Source Performance Standards: Coal Preparation Plants. EPA-340/1-77-022. November 1977.

29. Survey of Fugitive Dust from Coal Mines. EPA-908/1-78-003. February 1978.

30. PEDCo Environmental, Inc. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. EPA-450/3-77-010. March 1977.

31. Research Triangle Institute. Environmental Assessment of Coke By-Product Recovery Plants. EPA 600/2-79-006, NTIS PB 293278/AS. 1979.

SECTION 4

COST METHODOLOGY

4.1 STANDARDS AND ASSUMPTIONS

Cost Standards

Three basic costs have been determined: (1) total installed capital cost, (2) annual operating cost, and (3) annualized cost. These costs reflect 4th quarter 1978 dollars. The procedures for calculating installed capital costs for control equipment are presented in Section 4.2, as are the details of the capital recovery factor, the items included in the cost estimates, unit prices for labor, and other such information.

Process Standards

The flow diagram of a typical coke plant (Figure 7) and the corresponding flow diagram of a byproduct plant (Figure 8) indicate the scope of the processes included in the model.

The following constants are used the control cost calculations:

Useful life of battery	40 years
Days in year	365
Hours in day	24
Coke oven gas/ton wet coal	11,500 ft^3
Bulk density of wet coal	50 lb/ft^3
Bulk density of dry coal	44 lb/ft^3
Coking time	17.5 h for furnace coke 24.0 h for foundry coke 12.5 for preheated coal

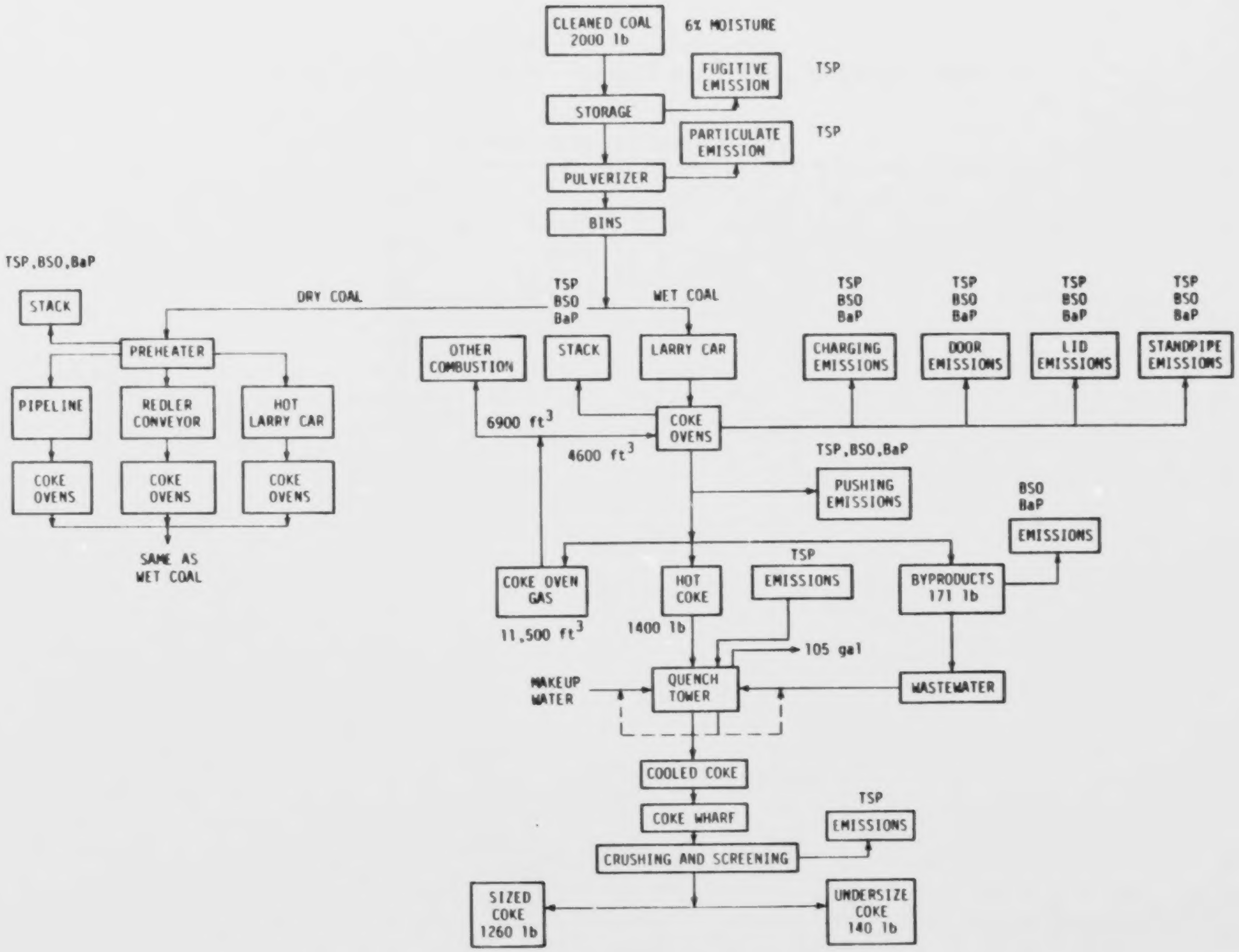
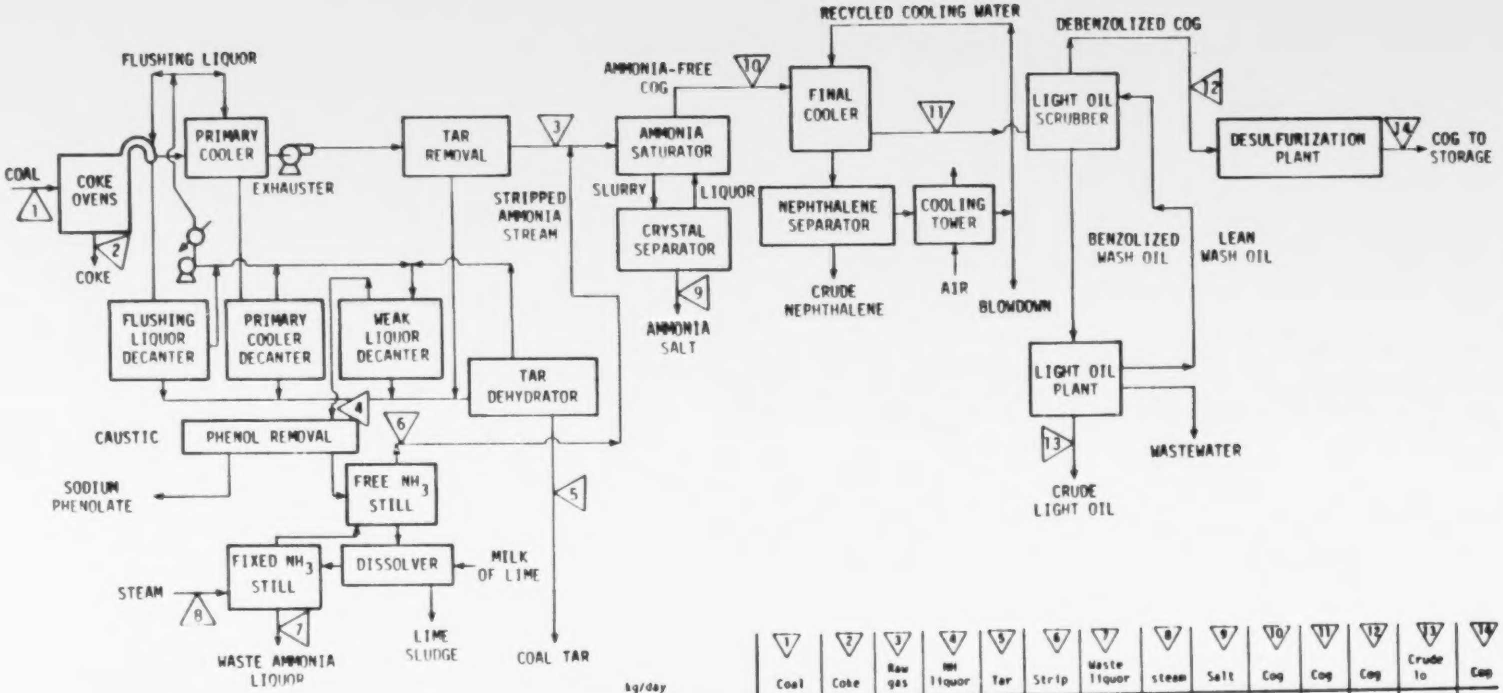

CLEANED COAL 2000 lb
6% MOISTURE
FUGITIVE EMISSION
TSP
STORAGE
PARTICULATE EMISSION
TSP
PULVERIZER
BINS
TSP,BSO,BaP
STACK
DRY COAL
TSP BSO BaP
WET COAL
PREHEATER
PIPELINE
REDLER CONVEYOR
HOT LARRY CAR
COKE OVENS
COKE OVENS
COKE OVENS
SAME AS WET COAL
OTHER COMBUSTION
STACK
LARRY CAR
6900 ft^3
4600 ft^3
COKE OVENS
TSP BSO BaP
CHARGING EMISSIONS
TSP BSO BaP
DOOR EMISSIONS
TSP BSO BaP
LID EMISSIONS
TSP BSO BaP
STANDPIPE EMISSIONS
TSP,BSO,BaP
PUSHING EMISSIONS
BSO BaP
EMISSIONS
COKE OVEN GAS
11,500 ft^3
HOT COKE
1400 lb
TSP
EMISSIONS
BYPRODUCTS 171 lb
105 gal
MAKEUP WATER
QUENCH TOWER
WASTEWATER
COOLED COKE
COKE WHARF
TSP
EMISSIONS
CRUSHING AND SCREENING
SIZED COKE 1260 lb
UNDERSIZE COKE 140 lb

Figure 7. Relationship of emission sources in a typical byproduct coke plant.


FLUSHING LIQUOR
COAL
1
COKE OVENS
2
COKE
PRIMARY COOLER
EXHAUSTER
TAR REMOVAL
3
STRIPPED AMMONIA STREAM
AMMONIA-FREE COG
10
AMMONIA SATURATOR
SLURRY
LIQUOR
CRYSTAL SEPARATOR
9
AMMONIA SALT
RECYCLED COOLING WATER
FINAL COOLER
11
NEPHTHALENE SEPARATOR
CRUDE NEPHTHALENE
COOLING TOWER
AIR
BLOWDOWN
DEBENZOLIZED COG
12
LIGHT OIL SCRUBBER
DESULFURIZATION PLANT
14
COG TO STORAGE
BENZOLIZED WASH OIL
LEAN WASH OIL
LIGHT OIL PLANT
13
CRUDE LIGHT OIL
WASTEWATER
FLUSHING LIQUOR DECANTER
PRIMARY COOLER DECANTER
WEAK LIQUOR DECANTER
TAR DEHYDRATOR
4
CAUSTIC
PHENOL REMOVAL
SODIUM PHENOLATE
6
FREE NH3 STILL
5
FIXED NH3 STILL
DISSOLVER
MILK OF LIME
STEAM
8
7
WASTE AMMONIA LIQUOR
LIME SLUDGE
COAL TAR

kg/day	1 Coal	2 Coke	3 Raw gas	4 NH liquor	5 Tar	6 Strip	7 Waste liquor	8 steam	9 Salt	10 Cog	11 Cog	12 Cog	13 Crude lo	14 Cog
Carbon solids	10,000[a]	7370												
Water	500		100	900	8	110	1040	250		240	140	130		130
Carbon dioxide			89	1		1				90	90	85		80
Hydrogen sulfide			29	1		1				30	30	30		2
Ammonia nitrogen			15	5		5			20					
Cyanide			4	1		1	Trace			5	3	3		
Chloride				1			1							
Gases H_2,Co,CH_4,N_2,O_2,HC			1500							1500	1500	1500		1500
Carbon disulfide			2							2	2		2	
Light oils			90		8					90	90	5	85	5
Tar acids				1	10		Trace							
Tar bases			2		10					2	2		2	
Polycyclics			1		340					1				
Other							Ca: 1		SO_4:53					
Totals	10,500	7370	1840	910	380	120	1040	250	73	1960	1860	1760	90	1720
Temperature °C			60	30	30	95	105	130		45	30	30		30
Pressure, bars			1.1			1.1		2.7		1.05	1.04	1.02		1.0

[a] Basis: the scale factor to Dunlop and McMichael (36) is 550

[b] Rounded

Figure 8. Flow plan and material balance of a representative coke byproduct recovery plant.[1]

Doors	Self-sealing (no luted doors)
Wet coal moisture	6 percent
Excess flushing liquor	45 gal/ton wet coal
Quench water requirement	150 gal/ton coke
Coke/coal yield	70 percent
Percent of gas used for underfire	40 percent

Flow rates:

Enclosed hot car, acfm	75,000
Enclosed shed, acfm	(0.67) x volume
Volume of shed	35.6 ft^3/ft of length per ton of coke pushed (T)
Length of shed (L)	4 ft x (No. of ovens) + 20 ft
Wet quenching, acfm	30,800 x T
Dry quenching, acfm	88 x (tons of coke/day)
Combustion stack, acfm	59 x (tons of coal/day) at 450°F @ 100% excess air
Coal preheater stack, acfm	16,900 x (10^6 tons of coal/year)

Temperatures:

The exhaust temperatures used are as follows:

Source	Temperature, °F
Charging	180
Pushing	300
Quenching	200
Doors	120
Topside	120
Combustion stack	450
Coal preheater	180

Table 3 shows the relationship between key oven parameters used to translate capacity data into the physical size data needed to determine certain costs. For example, oven volume is the key parameter for sizing larry-car hoppers, tons of coke per push is the key parameter for sizing an enclosed hot car, and oven height is a key parameter for determining shed cost. These

TABLE 3. RELATIONSHIPS OF SIZE AND OTHER PARAMETERS, COKE OVEN BATTERY

Basis: 50 ovens

Oven height, m	3	4	6
Oven volume, ft^3	540	720	1390
Tons coke/push	8.5	12.0	25.0
Without preheat			
Coking time, h	17.5	17.5	17.5
Pushes/day	68.6	68.6	68.6
Tons coke/yr[a]	213,000	300,000	626,000
With preheat			
Coking time, h	12.5	12.5	12.5
Pushes/day	96	96	96
Tons coke/yr[a]	296,000	420,000	876,000

[a] Directly proportional to number of ovens and inversely proportional to coking time.

relationships were used in calculating the cost functions for model input. For convenience the cost equations are expressed as a function of capacity. Because most batteries fall into one of the three categories shown in Table 3, the use of capacity as the cost variable is reasonable.

Two "interactions" are recognized in the model. An interaction is defined as a control of one source that effects control of another source. The interactions are as follows:

- The use of shed control on the pushing source effects control of coke-side door emissions. The removal efficiency is the same as that for pushing emissions except that only the coke-side door emissions are captured.
- The use of dry quenching on the quenching source effects control of pushing emissions because dry quenching utilizes an enclosed hot car. The cost of dry quenching also includes the cost of water treatment at those plants that would otherwise use dirty water for quenching.

4.2 PROCEDURE FOR COST ESTIMATING

Estimates for coke making systems are divided into two major categories, capital costs and annualized costs. Capital costs include such things as basic equipment and installation costs, contractors' fees, and taxes. Estimates are sometimes obtained directly from vendors and published information, or they may be based on engineering experience and judgment. Some elements of annualized costs also can be obtained from published information or other documented sources, whereas other elements (e.g., annualized overhead) must be calculated because they are dependent on capital costs.

The direct operating cost estimates in this report are based on engineering judgment unless otherwise noted. They reflect 4th quarter 1978 dollars based on the Chemical Engineering Plant Cost Index.

Capital Costs

Capital costs represent the total investment required to install a new control system. General factors that must be considered for any type of control device are total equipment cost, piping and ductwork, insulation, painting, and the like. Table 4 lists typical items included in investment costs of air pollution control systems.

System-specific factors affecting costs must also be considered. For coke oven systems these are capture method, temperature, effect on byproduct quality (if applicable), fuel storage (if applicable), and construction interest charges. Not included are production losses due to control equipment installation and startup and research and development costs.

The worksheet presented as Figure 9 organizes all capital investment cost factors for control systems into direct and indirect costs. Factors for the components in each group are calculated either as a function of the basic cost of the equipment or material (obtained from vendor quotations) or calculated specifically from engineering estimates (e.g., cubic yards of concrete required for foundations).

Annualized Costs

Total annualized costs include direct operating costs, capital charges, and overhead charges.

Direct operating costs include such items as utilities (fuel oil, natural gas, electricity, process water, etc.), operating labor (both direct and supervisory), maintenance and supplies (labor and material), and solid waste disposal.

Capital charges include depreciation, interest, administrative overhead, property taxes, and insurance. Depreciation and interest are computed from the total capital cost by using a Capital Recovery Factor (CRF), the value of which depends on the

TABLE 4. TYPICAL ITEMS INCLUDED IN INVESTMENT COSTS FOR CONTROL DEVICES

Total equipment cost, f.o.b. site

Device control instrumentation

Piping and duct work

Electrical equipment (motors, starters, conduits, etc.)

Insulation

Painting

Concrete and steel for foundations and support structures

Labor for equipment installation and materials application

Site preparation and building modifications

Construction management and supervision (contractor's fees)

Contingencies

Engineering and inspection

Startup

Freight charges for equipment and materials

Taxes and insurance

SUMMARY

PEDCo ENVIRONMENTAL DESCRIPTION ______________________________ DATE __________
PROJECT NO. __________ ______________________________ BY __________

DESCRIPTION	DETAIL SHEET	MATERIAL	LABOR	TOTAL
DIRECT COSTS				
1. Equipment				
2. Instrumentation				
3. Piping				
4. Electrical				
5. Foundations				
6. Structural				
7. Sitework				
8. Insulation				
9. Painting				
10. Buildings				
11. ________________				
12. ________________				
15. DIRECT SUBTOTAL				
INDIRECT COSTS				
21. Field Overhead				
22. Contractor's Fee				
23. Engineering				
24. Freight				
25. Offsite				
26. Taxes (5% x material)				
27. Allowance For Shakedown				
28. Spares				
29. ________________				
30. ________________				
31. INDIRECT SUBTOTAL				
35. SUBTOTAL				
41. Contingency (20% of line 35)				
42. Interest During Construction (10% of line 35)				
45. TOTAL				

Figure 9. Worksheet for estimating capital costs.

operating life of the system and on the interest rate.* For example, a CRF of 13.2 percent per year of the total capital costs is allowed for a system with a 15-year life expectancy and an interest rate of 10 percent. Property taxes and insurance are fixed together at 2.0 percent of the total capital cost per year. Administrative overhead charges are also fixed at 2.0 percent of the total capital cost.

Table 5 presents annualized operating cost factors used for control systems. Table 6 lists the specific rates used for computing the annualized costs for this particular study.

Modified/Reconstructed Facilities

The cost of installing a control system in an existing plant that has been modified, reconstructed, or expanded (given the same exhaust gas parameters) is greater than in a new plant because of special design considerations, more complex piping requirements, etc. It is difficult to estimate additional installation costs or retrofit penalty because many things are peculiar to an individual plant. Such factors as lack of space, additional ducting, and additional engineering have been considered here.

The location of the control system is governed by the configuration of the existing equipment. Long ducting runs from ground level to the control device and to the stack are sometimes required, depending on the location of the process or stack. Placing the control equipment above ground, which often requires steel structural support, may increase costs. Other cost components that may be increased because of space restrictions and plant configuration are contractor's fees and engineering fees. Under normal conditions these fees are estimated at 15 percent and 10 percent, but they can be expected to increase to 20 percent and 15 percent for a retrofit. Fees vary according to

---

* CFR = $\frac{i(1+i)^n}{(1+i)n-1}$ where i = interest rate (decimal factor) and
n = economic life of asset (No. years)

TABLE 5. ANNUALIZED OPERATING COST FACTORS FOR CONTROL SYSTEMS

- Direct operating costs
  - Utilities:
    - Fuel oil
    - Coal
    - Natural gas
    - Electricity
  - Operating labor:
    - Direct and supervisory (assume X shifts/day and X days/year to calculate hours/day)
  - Maintenance:
    - Labor
    - Materials
  - Supplies:
    - Labor
    - Materials
  - Solid waste disposal
  - Water treatment costs
- Capital charges
  - Depreciation and interest
  - Administrative overhead
  - Property taxes
  - Insurance
- Recovery credit adjustments

TABLE 6. RATES USED IN THE COST MODEL

Item	4th Quarter, 1978 dollars	Source
Water	0.161/1000 gal	a
Electricity	0.0266/kWh	a
Steam	4.13/M lb	b
No. 2 oil	0.42/gal	b
Natural gas	2.80/1000 ft^3	b
Coke oven gas	1.39/1000 ft^3	b
Direct labor	15.22/h	a
Supervisory labor	18.26/h	b
Compound MR dust control	3.69/gal	c
Bag cost (Lt 275°F)	0.28/ft^2	d
Bag cost (Gt 275°F)	0.44/ft^2	d
Sodium hydroxide	360/ton (100% basis)	e
Polyelectrolyte	2.48/gal	f
Solid waste disposal	8.25/ton	d
Payroll overhead	20% of payroll	d
Plant overhead	50% of labor and supplies	d
Interest rate	10%	d
Administration overhead	2% of installed cost	d
Property taxes and insurance overhead	2% of installed cost	d

[a] TBS (Reference 2).

[b] Calculated by PEDCo from rates in Reference 2.

[c] PEDCo Fugitive Dust Report. EPA-450/3-77-010. Reference 3.

[d] Estimated by PEDCo.

[e] Reference 4.

[f] Reference 5.

locale, difficulty of the job, the risks involved, and current economic conditions. PEDCo estimated the fees cited.

The required additional ducting varies considerably with plant configuration, but for purposes of this study, it is estimated that approximately 50 percent more ducting is required for a retrofitted control system.

Additional labor will be required to tie the system into the process, probably at premium-time wage rates (assumed to be double the straight-time pay).

When these additional cost factors are applied, the cost of retrofit installations generally runs about 20 percent higher than the cost of new installations; specific retrofit penalties are estimated individually for each module in the PEDCo cost model. Retrofit is not feasible in some plants, and these cases must be treated on a site-specific basis. The systems which are the most difficult to deal with as retrofits are dry coal charging and dry quenching. In the case of dry coal charging, there is the additional problem of apportioning cost between pollution control and increased production capability. Dry coal charging systems are included in the model only if they already are installed; retrofits to existing batteries are not included. Dry quenching is included with the provision that it may be not feasible for all plants.

Annualized Cost of Control Systems

The annualized costs of control systems for modified/reconstructed facilities are calculated in a manner similar to that for new facilities. The cost components that are based on capital costs are about 10 to 20 percent higher than those for new facilities.

REFERENCES FOR SECTION 4

1. Research Triangle Institute. Environmental Assessment of Coke By-Product Recovery Plants. EPA 600/2-79-006, NTIS PB 293278/AS. 1979.

2. Temple, Barker & Sloane. Analysis of Economic Effects of Environmental Regulations on the Integrated Iron & Steel Industry EPA-230/3-77-015B, July 1977.

3. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. Prepared for EPA by PEDCo Environmental, Inc. March 1977. EPA-450/3-77-010.

4. Chemical Marketing Reporter, October 9, 1978.

5. Personal communication between W. Kemner of PEDCo and D. Pietruszka of Betz Co., Trevose, Pennsylvania, 19047. June 1978.

SECTION 5

CONTROL SYSTEMS

This section provides a general description of each control option listed in Section 2 (Table 2). Further details such as exhaust temperature, duct diameter, and flow rate for each size of battery and plant are presented in the computer printouts for each control option in Appendix A. This section also provides a summary of capital and annualized costs for each option.

The cost estimates presented are based on engineering estimates by PEDCo, unless otherwise noted. Where applicable, the procedures described in Section 4.2 are used to derive the costs. For those control options that involve additional manpower or changes in operation and maintenance (rather than equipment), costs represent estimates of additional manhours required (sometimes based on related work previously performed by PEDCo).

5.1 GENERAL SPECIFICATIONS

Source 1--Larry Car Charging

Control Option 2: Modified Car, Steam, and Smoke Boot--

Modification costs are based on a standard four-hopper larry car. The basic modifications are the addition of a gooseneck cleaner, hydraulics for independent drop sleeve operation, a suction pipe (U-tube), stainless steel cones for hoppers, heat shields, new hopper discharge assemblies allowing independent operation, and a fume pipe for ventilation from the U-tube on Port 4 to Port 1. Costs also include all necessary engineering, assembly, and installation. Estimates are based on the assumption that the existing car is relatively new and that modifications are feasible. It is also assumed that headroom at the coal bunker is adequate. Estimates do not consider OSHA requirements for filtered air supply.

The steam supply considered in this option consists of a pressure regulating station, a 4-inch header along the battery, 1-inch takeoffs at each standpipe, and steam injection jets and the attendant miscellaneous piping, insulation, and installation.

Although the baseline for "uncontrolled" probably represents a battery already supplied with steam, it is assumed that the supply is not adequate to provide the quantity, pressure control, or the reliability necessary for good stage charging.

The final portion of this option involves a smoke seal for the leveling bar. The operating costs cover one additional lidman per shift (to insure timely lid replacement and luting) and one pipefitter on day shift to provide preventive maintenance for steam nozzle and liquor spray. Steam requirement is estimated at 24 lb/ton coke.

Control Option 3: New Car, Steam, Smoke Boot--

The new car included in Option 3 controls affords greater control because it is more reliable, and includes such design improvements as a gravity feed butterfly valve (Carbotek), and "two ovens-away drafting."

The car basically consists of four hoppers with flow control valves and drop sleeves, fume pipes between Ports 1 and 4 and Port 4 two ovens away, hydraulic slide gates, and gooseneck cleaner.

The battery steam supply and smoke boot are also included.

Many site-specific details of design will increase or decrease the cost from plant to plant. Furthermore, site-specific problems such as three-hole batteries, coal bunker clearance, warped battery tops, and off-battery-limit steam supply problems are not considered in the cost estimates.

The operating costs include the same additional manpower as described for Option 2. The additional costs for treating the condensed steam are not included, nor are potential losses due to deleterious effects of steam on tar quality (these should be addressed later in the refining of the fully developed model).

Control Option 4: Retrofit of Second Collecting Main Plus Option 3--

This option applies only to batteries with one collecting main, and includes the same features as Option 3 plus the retrofit of a second main. The estimate for the latter is based on the cost data in Reference 1. The reference does not indicate specifically what is included, but it is assumed that the second collecting main includes standpipes and goosenecks, collecting main, crossover mains across the battery top, steam and liquor spray systems, and a pressure regulating system. Such an installation is probably not feasible for batteries nearing the end of their useful life.

An additional refinement of the model could restrict usage of this option for older batteries because battery age is included in the battery data base. The model should also account for the probable decrease in door emissions afforded by a double collecting main, but presently this factor is ignored.

Source 2--Pushing

Control Option 2: Controlled Coking--

This option involves no capital cost--only annual operating costs. These include one additional man per shift for monitoring flue temperature and coking time. The major portion of the costs is based on an increase in average coking time of 17.5 to 19 hours. This represents an 8 percent loss in capacity (given that demand is at capacity). Lost production is valued at $110/ton of coke. For a battery with a capacity of 400,000 tons/year, the cost is (0.08) x (400,000) x ($110), or $3,520,000. At capacity utilization ratios below 92 percent, the cost thus calculated is theoretically zero, but periodic need for maximum output would still entail some lost production.

Control Options 3 and 6: Shed and Electrostatic Precipitator (ESP); Control Options 4 and 7: Shed and Scrubber--

The control efficiencies of the ESP are translated into cost by the relationship between efficiency and collection area shown below:[2]

Efficiency, %	Plate area, ft^2/1000 acfm of gas flow
99.9	385
99.0	240
95.0	188

The larger the plate area, the higher the control efficiency and the greater the control cost.

Aside from this factor, the general specifications for both of the shed ESP systems are identical as described here. The length of the shed is 4 feet per oven plus 20 feet of overhang. The exhaust volume is calculated according to the equation:

Exhaust volume in acfm = 1.67 (shed volume)

shed volume = 35.6 (L)(T)

where L = length of shed and

T = tons of coke per push

The shed includes foundations, columns, sheeting, internal lighting, and exhaust main along the length of the shed and under the exhaust main, an access walkway through shed. Figure 10 is a simplified cross section of the shed.

The shed system includes the shed, the ESP, the fan and drive, connecting duct work, the exhaust stack, and control dampers at the fans. As is the case for all air-moving systems, fan redundancy is 100 percent for fans smaller than 500 bhp and 50 percent over 500 bhp. For example, if the total horsepower required is 400 bhp, two 400 bhp fans are provided. For a total requirement of 1000 bhp, three 500 bhp fans are provided. Fan drive horsepower is based on standard air density of 0.075 lb/ft^3 to allow for cold starts.

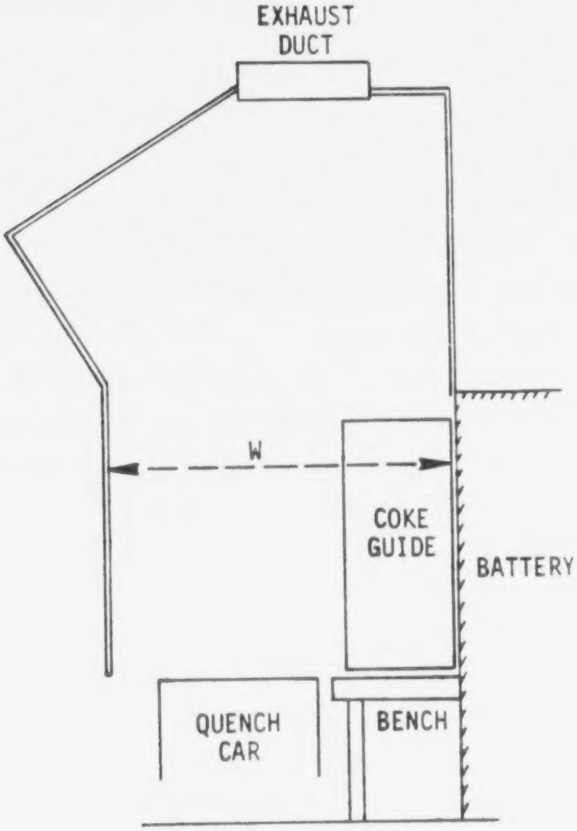

EXHAUST
DUCT
W
COKE
GUIDE
BATTERY
QUENCH
CAR
BENCH

Figure 10. Cross section of coke-side shed.

The redundancy of the ESP is 20 percent of the plate area required. The ESP's are insulated and covered and include dust-handling hoppers and conveyors. Duct diameters are based on a duct velocity of 4000 ft/min. Stack diameters are based on a stack velocity of 3000 ft/min. The 300 ft of duct work for the shed is unlined and uninsulated carbon steel, as is the 100-ft stack. Fans are induced-draft and centrifugal with radial-tipped blades, and are rated for material handling (MH). The totally enclosed motors are drip-proof and have oil-cooled bearings as required. The fan electrical system includes motor starters, louver operators, annunciators and related switches, and wiring. No allowance is made for additional substations or increasing plant electrical capacity.

The only difference in the scrubber systems is that the ESP is substituted with an unlined stainless steel venturi scrubber and mist eliminator. Total system pressure drop is 50 in. H_2O for a 99 percent TSP collection efficiency and 30 in. H_2O for a 95 percent collection efficiency. (These are initial estimates only and can be refined later.) The L/G ratio of the scrubbing liquor is 7.9. Wastewater is recycled through a treatment system, which includes a clarifier-vacuum filter section, a wastewater recirculating pump, and a makeup water pump. It is assumed that this system will have a 5 percent blowdown rate to an existing water treatment system for removal of dissolved compounds such as phenol and cyanide.

The shed systems are assumed to capture coke-side door emissions in addition to 90 percent of the pushing emissions. Coke-side door emissions are assumed to be 50 percent of total door emissions.

Control Option 5: Enclosed Hot Car--

The enclosed hot car used in this option is described in the literature and in Reference 2. Equipment costs are based on a rough quote by Chemico; indirect costs were added by PEDCo. No separate allowance is made for reenforcement or modification of the bench or for modification of the quench tower or wharf except as they might be included in a gross estimate represented by the retrofit factor. The Chemico car was chosen from a variety of designs to represent this general class of control. Additional variations can be added to the model if desired.

Source 3--Quenching Clean Water

Control Option 2: Wooden Baffles--

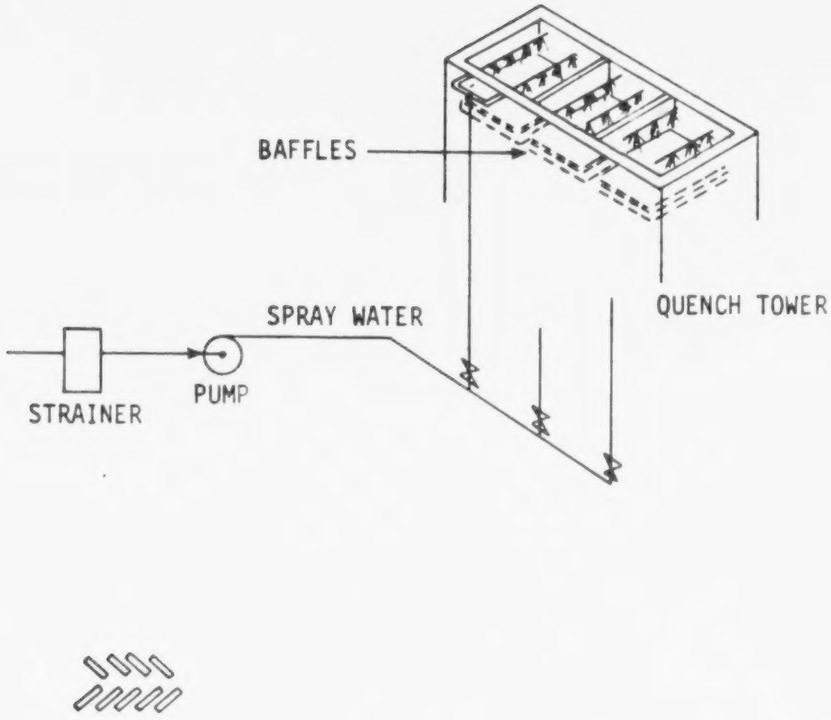
The cost of quench tower controls is a function of the number of quench towers in the plant rather than of coking capacity. Because specific data are not available on the number of quench towers required, it is assumed that one quench tower can handle up to 900,000 tons/yr of coke production. Figure 11 shows the scope of this option.

Control Option 3: Diverted Flow Baffles--

The total installed capital cost of a diverted-flow, baffled quench tower was estimated by PEDCo based on a brochure from Firma Carl Still. The estimate includes baffles, water system, and quench tower extension. It does not include dismantling of an existing tower and total replacement by a new quench tower. Operating costs are calculated to be about 10 percent of the total capital cost. The number of quench towers required is calculated as indicated under Option 2.

Control Option 4: Dry Quenching--

Costs are based on a system such as that shown in simplified form in Figure 12, which was derived from a brochure by American Wagner Biro Company. This system includes enclosed pushing hardware, which is accounted for in the model; i.e., when dry quenching is used, pushing control is put at level 5. Because no U.S. plants use dry quenching and the steam generated might not be useful to the plant, the potential steam credit is not considered here. If it were, the annualized cost would become negative, which would complicate the optimization model. If desired, however, the cost update program can be used to generate


BAFFLES
QUENCH TOWER
SPRAY WATER
STRAINER
PUMP

TYPICAL BAFFLE ARRANGEMENT

Figure 11. Conventional quench tower baffles.

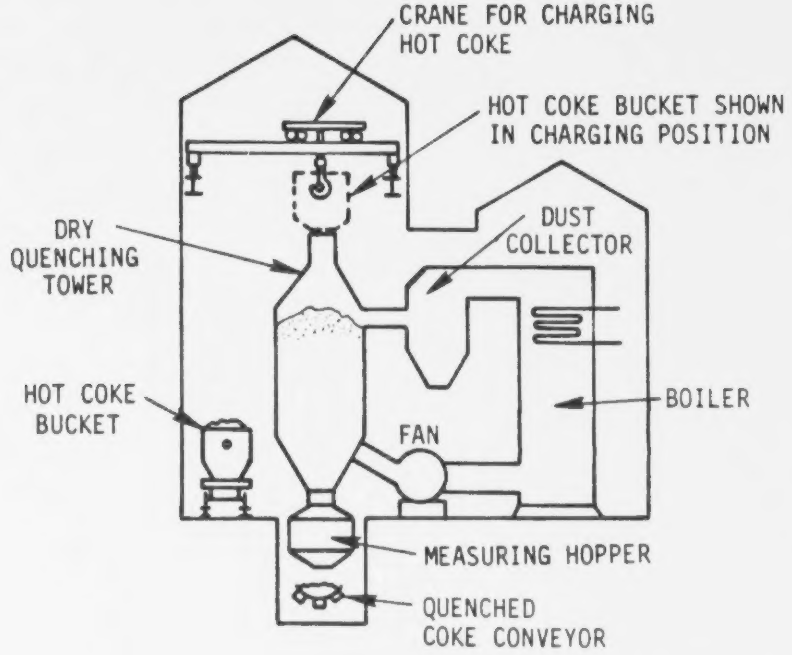

CRANE FOR CHARGING HOT COKE
HOT COKE BUCKET SHOWN IN CHARGING POSITION
DRY QUENCHING TOWER
DUST COLLECTOR
HOT COKE BUCKET
BOILER
FAN
MEASURING HOPPER
QUENCHED COKE CONVEYOR

Figure 12. Simplified pictorial diagram of a dry quenching system.

revised cost functions for dry quenching, which do account for steam credit. There are some relatively small plants (less than 100,000 tons of coke per year) in the data base for which dry quenching is probably not feasible. It is also questionable whether the present cost function is applicable in this small range. These issues can be further investigated as a later refinement.

Source 4--Doors

Control Option 2: Cleaning and Maintenance--

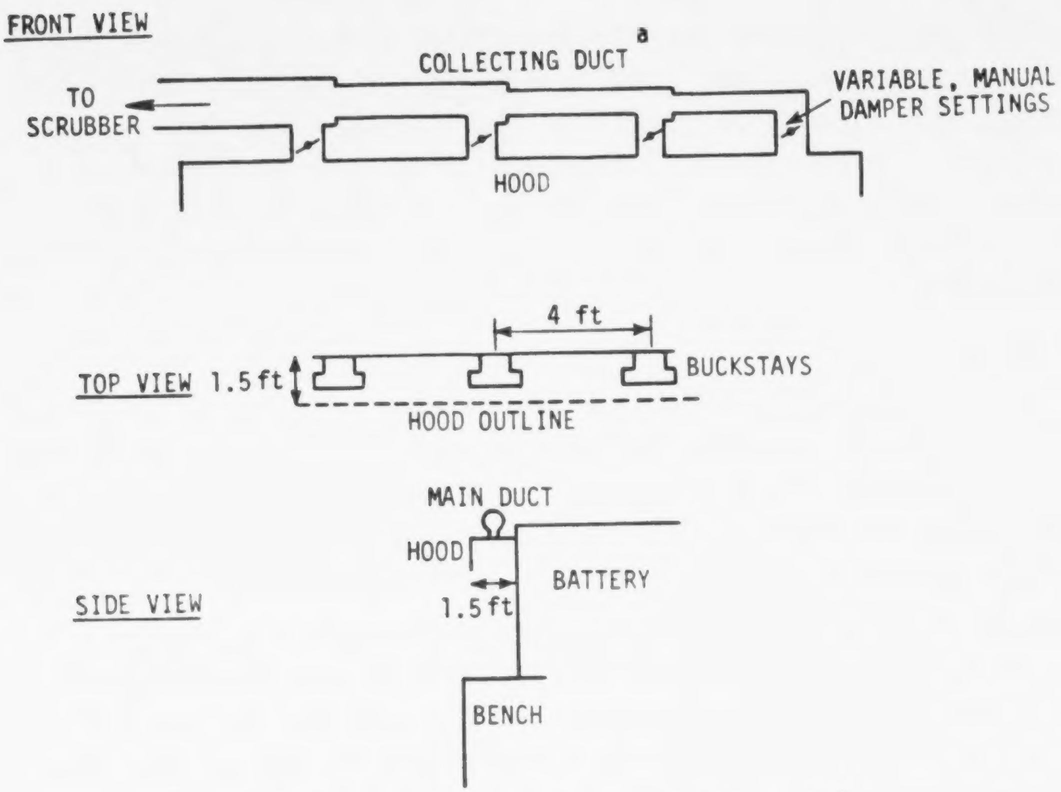
This option involves no capital cost. The annual operating cost is based on the addition of two men/shift for cleaning, door inspection, and repair. Maintenance costs also include the cost of door replacement at a rate of 10 percent per year.

Control Option 3: High Pressure Water Cleaning--

This option entails the installation of two (one per side) high-pressure water-cleaning machines, either on the existing pusher and door machines or on a separate car. Costs are based on a rough quote by Industrial High Pressure Systems, Inc. It is assumed that the existing pusher and door machine operators will operate the cleaning units. The option requires the addition of one man/shift for troubleshooting and inspection. Cost of replacement doors is the same as for control Option 2.

Control Options 4 and 5: Door Hood and Scrubber--

The scrubber, duct work, fans, and auxiliaries used in this control option are generally of the same specification as previously described. An unlined stainless steel venturi is used with a mist eliminator. The scrubber efficiency at 30 in. H_2O pressure drop is estimated to be 95 percent; at 60 in. H_2O, 98 percent. The water treatment system is the same as described under Source 2. The duct length included is 150 ft plus the length of ducts along both sides of the battery calculated as four feet per oven per side. Stack height is 100 feet. Both are constructed of unlined, uninsulated, carbon steel. Figure 13 presents a sketch of the system and indicates the required flow


FRONT VIEW
COLLECTING DUCT[a]
TO SCRUBBER
VARIABLE, MANUAL DAMPER SETTINGS
HOOD
4 ft
TOP VIEW
1.5 ft
BUCKSTAYS
HOOD OUTLINE
MAIN DUCT
HOOD
BATTERY
SIDE VIEW
1.5 ft
BENCH

DOOR FACE AREA = (1.5 ft) x (4 ft) = 6 ft^2
NUMBER OF OVENS EXHAUSTED AT ANY GIVEN TIME = 6
FACE VELOCITY = 200 ft/min FOR 75% CAPTURE
FACE VELOCITY = 250 ft/min FOR 85% CAPTURE
FLOW RATE (ONE SIDE) = (6 ft^2) x (6) x (200 ft/min)
= 7200 acfm
TEMPERATURE = 100°F
FLOW RATE = 6800 scfm
FLOW RATE (BOTH SIDES) = 13,600 scfm FOR 75% CAPTURE
= 17,000 scfm FOR 85% CAPTURE

[a] IN ACTUAL PRACTICE, DUCT WOULD BE OF VARYING DIAMETER AND REQUIRE SOME DAMPER ARRANGEMENT TO DISTRIBUTE FLOW ALONG LENGTH OF BATTERY. THE COST ESTIMATE IS NOT OF SUFFICIENT DETAIL TO RECOGNIZE SUCH DETAILS. DUCT COST THEREFORE IS BASED ON A CONSTANT DIAMETER.

Figure 13. Door hood arrangement.

rate. Also included in the cost of this option are the costs described under Option 2.

Source 5--Topside

Control Options 2 and 3: Luting, Cleaning and Maintenance--

These two control options entail no capital costs and differ only in degree. Option 2 includes one additional man/shift for inspection and luting of lids and standpipes (in addition to the lidman and larry car operator). For Option 3, additional maintenance hours are added for grouting lid seats and standpipe bases and replacing faulty lids and caps. The cost estimate is based on an additional 1000 hours/year of labor plus the cost of supplies.

Control Option 4: New Lids and Seats--

The cost of this option includes one additional man/shift for inspection and luting of lids and standpipes plus an additional capital cost for new lids and seats at a rate of four lids per oven. This option is not applicable to preheated coal batteries.

Source 6--Combustion Stack (Old)

Control Option 2: Oven Patching--

The arbitrary definition of "old" combustion stack is based on a battery age of 15 years or older. This option involves the cost of 5900 maintenance hours per year for oven spraying and patching on a regular basis and one additional man around the clock for inspection and adjustments to the heating system. No capital costs are included.

Control Options 3 and 4: Dry ESP--

The control efficiencies of ESP's are related to cost in that higher efficiencies require larger collection areas, as shown below:[2]

Efficiency, %	Plate area, ft^2/1000 acfm of gas flow
90.0	232
98.0	450

General ESP specifications are the same as those described under Source 2. The length of duct allowed is 150 ft; duct work is brick lined carbon steel. In the case of retrofits, it is assumed that the duct is tied into the existing flue and the existing stack is used. A booster fan with a total static pressure capacity of 6 in. H_2O is added. The flow rate for this source is calculated as:

acfm = 59 x tons coal/day

with an exhaust temperature of 450°F. This flow is based on a stoichiometric calculation for coke oven gas with 100 percent excess air.[3] Costs for flue gas conditioning are not included. A separate ESP system is provided for each battery although, in specific cases, it might be feasible to use a common ESP for adjacent batteries. Because of space limitations and problems with duct tie-in, the retrofit of an ESP to underfire stacks may not always be possible. The ability to shut the gas off to an existing battery long enough to accomplish tie-in without damaging oven refractories is a site-specific problem and is not addressed in this study.

Control Option 5: Baghouse--

This option is the same as Options 3 and 4 except that a fabric filter is substituted for the ESP. Temperature to the baghouse is limited by increasing the rate of air flow sufficiently to reduce the temperature from 450° to 275°F. The resulting flow rate is about 1.85 times that flow used for Options 3 and 4. The air-to-cloth ratio used is 3.0.

Source 7--Coke Handling

Control Option 2: Enclosures and Baghouse--

Specific details of this control system for emissions from coke handling will vary from plant to plant. The generalized system used in the model consists of a plain carbon steel hood over the primary screen and five conveyor transfer point enclosures vented to a fabric filter having an air-to-cloth ratio of 6.0. Duct work is unlined, uninsulated, plain carbon steel of variable length depending on plant size. The average length is 75 ft. An exhaust fan with a static pressure rating of 8 in. H_2O is included. Flow rate is based on standard ventilation formulas for hoods and appropriate conveyor belt widths.[2] The control system is rated to accommodate the total coking capacity of a plant and is based on the assumption that a common coke-handling station serves all batteries. This is a safe assumption because only a few plants have widely separated groups of batteries and more than one handling and loadout station. The system does not include controls at the coke wharf.

Source 8--Coal Preheater

Control Options 2 and 4: Wet Scrubber--

The control options for this source are applicable only to those few batteries that have coal preheating systems. The two scrubber options are identical except in pressure drop requirement and concomitant fan capacity. Both scrubbers are stainless steel and contain corrugated-baffle mist eliminators. Both options include 100 ft of carbon steel duct work and a 100-ft stack. Flow rate (in acfm) is calculated according to the following formula:

$$\text{acfm} = 16{,}900 \times \left(\frac{\text{tons of coal/year}}{1{,}000{,}000}\right)$$

Control Options 3 and 5: Dry ESP--

These options are similar to the scrubber options except they call for ESP's rather than wet scrubbers. No data are available on the collection area required for coal preheater exhaust. Based on the assumption that preheater particulate emissions are similar to underfire stack emissions, the following values are used:[2]

Efficiency, %	Plate area ft^2/1000 acfm of gas flow
95.0	324
99.0	538

Source 9--Coal Preparation

Control Option 2: Enclosures and Baghouse--

The sources of coal preparation emissions are the crushing, mixing, and transfer steps that occur between the initial coal-receiving station and the coal storage bunkers at the battery. The size of the control system is determined by the coal capacity of the plant. The system includes six conveyor transfer-point hoods vented to a fabric filter having an air-to-cloth ratio of 6.0. Duct length varies with plant size, but the average is 250 ft. The system also includes an exhaust fan with a static pressure capacity of 8 in. H_2O.

Source 10--Coal Storage Yard

Control Option 2: Spray Truck--

This option consists of a standard tractor trailer outfitted with a spray system and water storage tank. The estimated efficiency rating is 60 percent, but little data are available on dust control of coal storage piles. It is assumed that the truck would be used during periods of dry weather or windy conditions to suppress emissions at these most critical times. Operating costs include driver time, dust suppressant chemicals, and truck maintenance.

Control Option 3: Unloading Sprays and Spray Truck--

In addition to a spray truck, control Option 3 includes a spray system at the car dumper (or barge unloading station). The system is shown in Figure 14. Control efficiency should be increased from 60 to 75 percent with the application of option. This increase is based not only on the suppression of emissions during dumping, but also on the assumption that application of a dust suppressant provides more thorough and longer lasting control than water spraying alone.

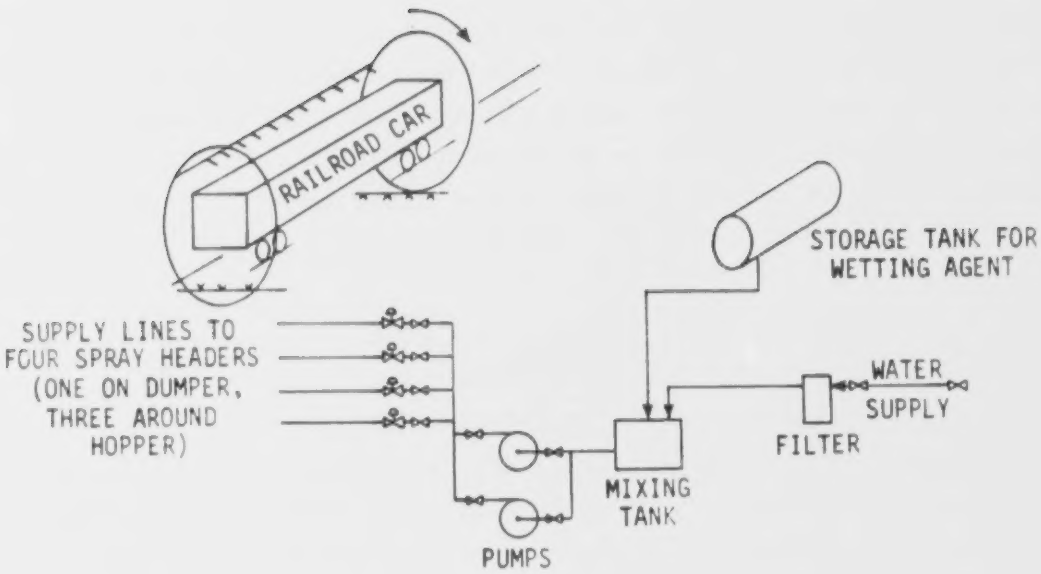

RAILROAD CAR
STORAGE TANK FOR WETTING AGENT
SUPPLY LINES TO FOUR SPRAY HEADERS (ONE ON DUMPER, THREE AROUND HOPPER)
WATER SUPPLY
FILTER
MIXING TANK
PUMPS

Figure 14. Dust-supression spray system at car dumper.

Source 10--Coal Storage

Control Option 4: Coal Pile Sprays--

This control option (shown in Figure 15) is much more expensive than Options 2 and 3. It consists of permanently installed spray stanchions around the perimeter of the coal piles. These stanchions can be regulated at a central pump house. The lines are insulated and heated for winter operation. The size of the system is based on the amount of storage area required (based on a coal pile storage density of 0.28 ton/ft^2).[2] The control options for Source 10 are based on total plant capacity. Cost estimates are independent of battery characteristics.

Source 11--Pipeline Charging; Source 12--Redler Conveyor Charging; and Source 13--Hot Larry Car Charging

Control Option 2: Operation and Maintenance--

Information concerning controls for dry-coal charging systems (Sources 11, 12, and 13) is limited. These sources represent topside emissions from batteries charged with dry coal. Emission controls for such sources as doors and stacks are the same as those in conventional batteries. The control of emissions from hot larry car loading at the coal bunker is not considered because there is only one such battery and controls were included in its design.

A recent study of pipeline-charged batteries and Redler-charged batteries suggests such controls as additional steam aspiration, better seals at discharge ports, and slower charging rates.[4] Because specific controls have not been selected, however, a capital cost cannot be determined. Cost estimates present only an annual operating cost based on the addition of one topside worker for inspection, luting, and minor maintenance of lids, standpipes, and the pipeline or conveyor.

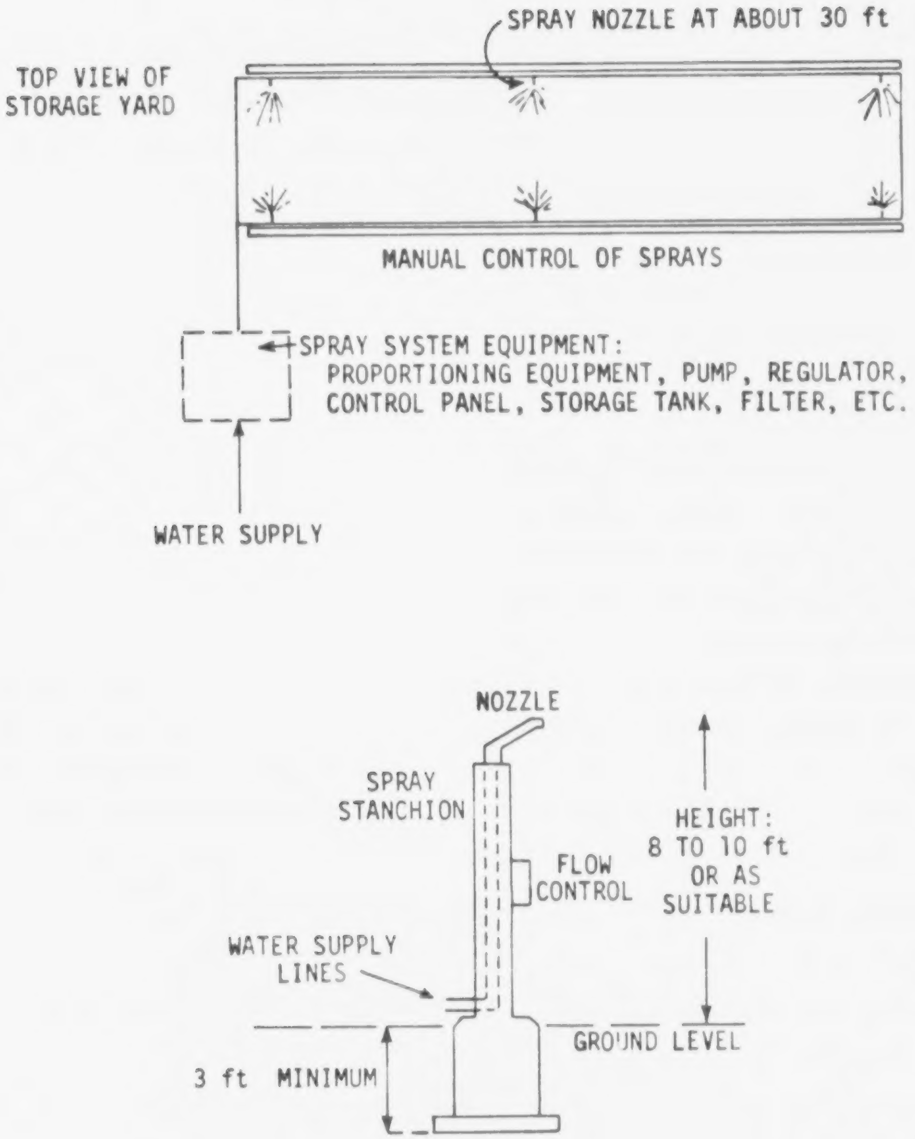

SPRAY NOZZLE AT ABOUT 30 ft
TOP VIEW OF STORAGE YARD
MANUAL CONTROL OF SPRAYS
SPRAY SYSTEM EQUIPMENT:
PROPORTIONING EQUIPMENT, PUMP, REGULATOR, CONTROL PANEL, STORAGE TANK, FILTER, ETC.
WATER SUPPLY
NOZZLE
SPRAY STANCHION
FLOW CONTROL
HEIGHT: 8 TO 10 ft OR AS SUITABLE
WATER SUPPLY LINES
GROUND LEVEL
3 ft MINIMUM

Figure 15. Permanently installed spray stanchions around perimeter of coal piles.

Source 14 - Byproducts Plant

Control Option 2: Maintenance--

No control systems or procedures have yet been developed for the control of air emissions from byproduct plants. So that a working model recognizing this potential emission source could be provided, a control option consisting of 8760 hours/year of inspection and maintenance has been used. This includes valve packing, tank patching, and repair of pipe leaks, and should produce a control efficiency of 80 percent. These data are artificial data, however, and are used only to provide a complete dataset for the model.

Source 15--Combustion Stack (New)

Control Option 2: Oven Patching--

The designation of a battery stack as "old" or "new" is arbitrary and is used only to help explain broad variations in uncontrolled emissions. If site-specific data classifying each stack according to emission level were available, the designation of age as a parameter could be eliminated. Oven patching is the same as the control option described for old battery stacks, and it is the only control option used for new stacks because more extensive measures are not necessary.

Source 16--Quenching With Dirty Water

Control Option 2: Wooden Baffles--

This option is identical to that shown in Figure 11 (for Source 3, Option 2).

Control Option 3: Clean Water and the Use of Baffles--

The most definitive study available on the subject of emissions from quenching is by Edlund.[5] The study addresses only particulate emissions. Figure 16 illustrates the relationship between emissions and dissolved solids in the quench water. Determining the total dissolved solids for each plant is beyond

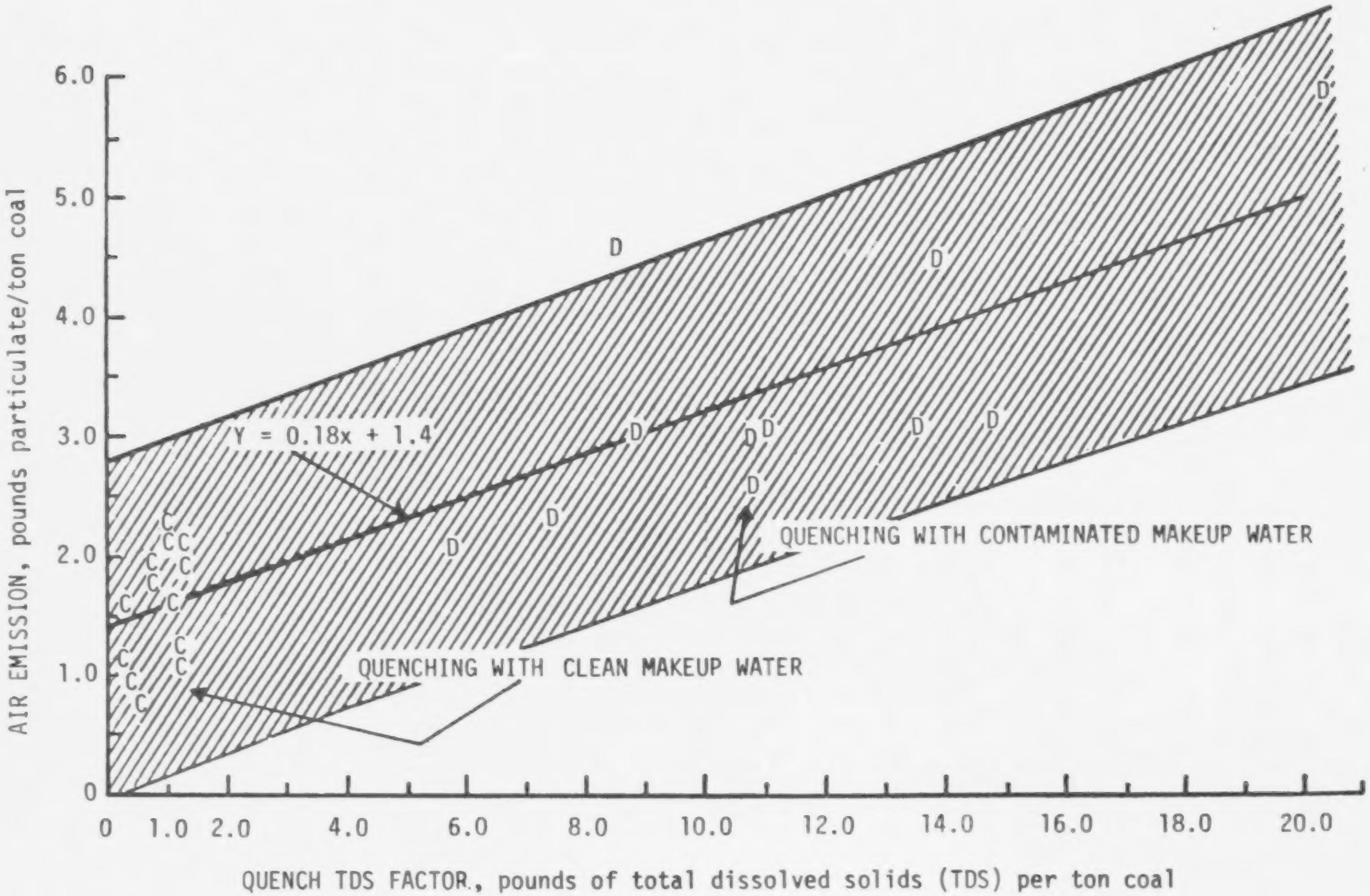


Figure 16. Total particulate emissions from coke quenching.[5]

the scope of this project, but it is known that the composition of process water varies from plant to plant, as does the ratio of process water to quench water. The total amount of process water also varies. Table 7 (extracted from a preliminary summary of Effluent Guidelines 308 Questionnaire Data) shows these variations.[6]

The variations in quench water composition and the many different water treatment methods used require some assumptions for simplification:

1. Plants are designated as using either clean water or dirty water for quenching. The particulate emission rates are assumed to be 1.7 lb/ton of coal for clean water and 3.2 lb/ton of coal for dirty water.

2. The control scheme for treating dirty water (instead of using it for quenching) is an ammonia distillation column using caustic soda, a bio-oxidation plant with 3-day retention time, and activated carbon filters for polishing. An incinerator is included for incinerating the ammonia vapors, although these could be recovered and converted to useful byproduct. A flow sheet of this system is presented in Figure 17. It is assumed that water thus treated becomes acceptable effluent and that river water (i.e., clean water) is used for quenching.

3. The quantity of water to be treated is assumed to be 150 gal/ton of coke. (It should be noted that the control option of dry quenching must include the treatment of the dirty water that would otherwise have been used for quenching). The plant is sized for 50 percent excess capacity to enable recovery from outages.

4. When dry quenching and wastewater treatment are used in combination, it is assumed the steam generated by the dry quenching system is used to displace the steam requirement of the water treatment system.

Although these are significant assumptions that could affect the usefulness of the model, they are necessary to establish a starting point. More detailed data and additional control schemes can be factored into the model at some later date.

The other control options for quenching have already been described.

TABLE 7. COKE PLANTS USING PROCESS WATER FOR QUENCHING

Reference No.	Company	Location	Excess NH_3 liquor	Benzol plant	Final cooler	Barometric condenser	Desulfurizer	Other[a]	Total, gal/min	Process wastewater as % of total quench volume	Process wastewater in gal/ton
0012A	Alabama B.P.	Tarrant, Ala.			145				145	11.1	93
0112B	Bethlehem	Lackawanna, N.Y.			120	100		5	225	5.6	50
0112C(Rose)	Bethlehem	Johnstown, Pa.	18	14	5			5	42	12.9	60
0112C(Frank)	Bethlehem	Johnstown, Pa.	58	64	10			28	160	11.1	74
0112D	Bethlehem	Chesterton, Ind.			505	230	765	270	1770	53.9	493
0256E	Cyclops-FMP DET.	Portsmouth, Ohio	110						110	98.1	139
0280B	Philadelphia Coke	Philadelphia, Pa.			70				70	18.3	121
0384(#2)	Inland	E. Chicago, Ind.		295	125			10	430	16.7	100
0384(#3)	Inland	E. Chicago, Ind.						100	100	13.8	90
0432A	J&L	Aliquippa, Pa.	166	104	125	28		70	493	64.5	323
0448A	Kaiser	Fontana, Calif.	97	42	1				140	43.8	49
0464E	Koppers	Bessemer, Ala.			150				150	57.6	144
0584C	National	Granite City, Ill.	52		10				62	7.1	51
0584F(Main)	National	Weirton, W. Va.		32.5	29				61.5	22.1	39
0684A	Republic	Youngstown, Ohio	100	20	5			30	155	11.1	81
0684B	Republic	Warren, Ohio	50	50	10			20	130	16.3	146
0684F(1)	Republic	Cleveland, Ohio		209					209	62.1	93
0684F(2)	Republic	Cleveland, Ohio		56					56	28.3	42
0732A	Shenango	Neville Island, Pa.			80				80	16.2	73
0856F	USS	Fairless Mills, Pa.			2.5	5		100	107.5	10.3	52
0856N	USS	Lorain, Ohio	167	73		71			311	72.8	103
0860B	USS	Gary, Ind.	278		174				452	7.6	65
0864	USS	Geneva, Utah	90	75	100				265	70.7	106
0948A	YS&T	Campbell, Ohio	90	61	175				326	92.2	123

---

[a] Includes larry car scrubber wastewaters, shed scrubbers, gas holder seals, preheater condensates, drains and seals on gas mains, and miscellaneous floor drains.

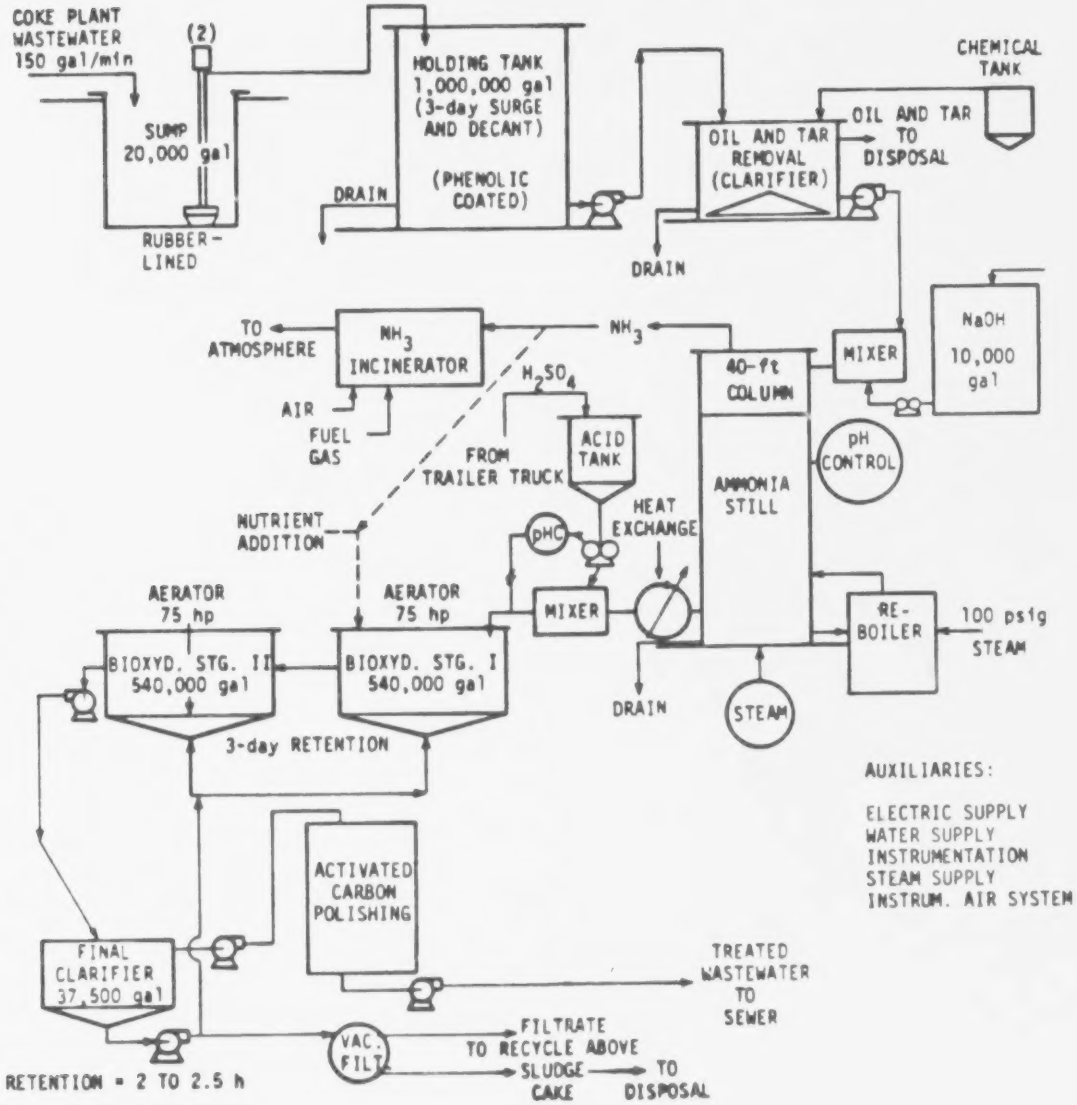

COKE PLANT WASTEWATER 150 gal/min
(2)
SUMP 20,000 gal
RUBBER-LINED
HOLDING TANK 1,000,000 gal (3-day SURGE AND DECANT)
(PHENOLIC COATED)
DRAIN
CHEMICAL TANK
OIL AND TAR REMOVAL (CLARIFIER)
OIL AND TAR TO DISPOSAL
DRAIN
NaOH 10,000 gal
MIXER
TO ATMOSPHERE
NH_3 INCINERATOR
NH_3
AIR
FUEL GAS
H_2SO_4
FROM TRAILER TRUCK
ACID TANK
40-ft COLUMN
AMMONIA STILL
pH CONTROL
HEAT EXCHANGE
NUTRIENT ADDITION
pHC
MIXER
AERATOR 75 hp
AERATOR 75 hp
BIOXYD. STG. II 540,000 gal
BIOXYD. STG. I 540,000 gal
3-day RETENTION
RE-BOILER
100 psig STEAM
DRAIN
STEAM
AUXILIARIES:
ELECTRIC SUPPLY
WATER SUPPLY
INSTRUMENTATION
STEAM SUPPLY
INSTRUM. AIR SYSTEM
ACTIVATED CARBON POLISHING
FINAL CLARIFIER 37,500 gal
TREATED WASTEWATER TO SEWER
VAC. FILT.
FILTRATE TO RECYCLE ABOVE
SLUDGE CAKE
TO DISPOSAL
RETENTION = 2 TO 2.5 h

Figure 17. Coke plant wastewater treatment system.

REFERENCES FOR SECTION 5

1. Draft of Standards Support and Environmental Impact Statement. Volume I: Proposed National Emission Standards By-product Coke Oven Wet Coal Charging and Topside Leaks. U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. June 1978.

2. Development of Air Pollution Control Cost Functions for the Integrated Iron and Steel Industry. (Draft) Prepared by PEDCo Environmental, Inc., Cincinnati, Ohio, for the U.S. EPA, Office of Air Quality Planning and Standards, Washington, D.C., under Contract No. 68-01-4600. September 1978.

3. Midwest Research Institute. Study of Coke Oven Battery Stack Emission Control Technology Volume II, Control Methods. Prepared for Emission Standards and Engineering Division. U.S. EPA Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EPA Contract 68-02-2609, Task 5. March 1979.

4. PEDCo Environmental, Inc. Control of Emissions from Dry Coal Charging at Coke Oven Batteries. Prepared for U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EPA Contract 68-02-2603, Task 28. October 1978.

5. Edlund, Carl, A.H. Laube, and J. Jeffrey. Effects of Water Quality on Coke Quench Towers Particulate Emissions.

6. Personal communication with Mr. Bernie Bloom, DSSE, Washington, D.C. to W. Kemner, PEDCo. September 14, 1978.

SECTION 6

BATTERY DATA BASE (DATASET 3)

This dataset provides a record of the following for each battery in the United States:

- Company location code
- Date installed or date of last major rebuilding
- Number of ovens
- Capacity, tons of coke/year
- Type of charging used
- Oven height
- Number of collecting mains
- Control equipment in place

These data are used as input to the model to determine total coke industry emissions and the costs to control them.

The data base for coke oven batteries was assembled from a variety of documents, some of which provide conflicting information.[1-6] Most of the capacity data is from Reference 1. Where given data conflicted, PEDCo used its own expertise and knowledge of the industry to select data values for use in the model. For most of the foundry coke batteries, the main data source was Reference 6.

The scope of this project does not cover the development of a detailed data base for the U.S. coking industry, but it was necessary to prepare a reasonably accurate census to estimate control costs.

Input of the battery data is arranged so that it can be updated easily as additional data become available. Although some of the data are estimated and some may be outdated, most of the industry is correctly represented in the census, and the aggregate costs calculated from the current data base should be representative.

Table 8 represents the data base provided to the model. Figure 18 shows the data coding form used to change or update the data base. Table 9 presents the plant ID codes used for the data coding form.

Total industry cost for a given control option and efficiency are calculated generally as:

$$\text{Industry cost} = \sum_{i=1}^{n} A \cdot X_i^B$$

where A and B = cost coefficients from the cost model

X_i = capacity (tons coke/year) for battery i

n = total number of batteries

Company names are used only for convenience in coding and keeping track of the data. This study is not source-specific, and company names will not appear in the model printout.

In this model, plant capacity has generally been used as the variable in determining control costs. Certain costs, however, are not strictly a function of capacity. Shed cost, for example, is a function of oven height and number of ovens. In the case of quench towers, on the other hand, cost is proportional to the size and number of towers. The slight inaccuracies introduced by the use of capacity as the cost variable, however, are not of major concern in this stage of model development. In the case of quench tower baffles, it is assumed that one quench tower can handle up to 2500 tons of coke per day. For coal yards, coal preparation, coke processing, and byproduct plants, the model calculates costs for entire plants rather than individual batteries (i.e., X_i becomes the total capacity of all batteries in a plant).

Certain other site-specific factors could affect cost. For example, the economy of scale gained by combining two or more adjacent batteries under a common control device to control

TABLE 8. COKE OVEN MODEL - BATTERY DATA BASE PAGE 1

PLANT NO	INST. DATE	NO. OVENS	COKE CAPACITY TONS/YR	CHARGING	HEIGHT (METERS)	PUSH CONTROL	QUENCH WATER	NO. COLL. MAINS
1	1966	55	220000.	LARRY CAR	3	NONE	CLEAN	1
1	1967	55	220000.	LARRY CAR	3	NONE	CLEAN	1
2	1938	15	80000.	LARRY CAR	4	NONE	CLEAN	1
2	1941	25	130000.	LARRY CAR	4	NONE	CLEAN	1
2	1947	25	130000.	LARRY CAR	4	NONE	CLEAN	1
2	1952	76	540000.	LARRY CAR	4	NONE	CLEAN	2
2	1961	45	240000.	LARRY CAR	4	NONE	CLEAN	1
2	1976	57	670000.	LARRY CAR	6	ENCLOSED CAR	CLEAN	2
2	1977	57	670000.	LARRY CAR	6	ENCLOSED CAR	CLEAN	2
4	1942	47	190000.	LARRY CAR	4	SHED	CLEAN	1
4	1953	15	190000.	LARRY CAR	4	SHED	CLEAN	1
5	1941	51	400000.	LARRY CAR	3	NONE	DIRTY	1
5	1942	51	400000.	LARRY CAR	3	NONE	DIRTY	1
5	1953	80	440000.	LARRY CAR	4	NONE	DIRTY	1
5	1976	80	890000.	LARRY CAR	6	OTHER	DIRTY	2
6	1915	63	260000.	LARRY CAR	3	NONE	CLEAN	1
6	1918	63	260000.	LARRY CAR	3	NONE	CLEAN	1
6	1920	63	260000.	LARRY CAR	3	NONE	CLEAN	1
6	1922	63	260000.	LARRY CAR	3	NONE	CLEAN	1
6	1929	63	250000.	LARRY CAR	3	NONE	CLEAN	1
6	1936	60	260000.	LARRY CAR	3	NONE	CLEAN	1
6	1941	61	310000.	LARRY CAR	4	NONE	CLEAN	1
6	1948	61	310000.	LARRY CAR	4	NONE	CLEAN	1
6	1950	65	350000.	LARRY CAR	4	NONE	CLEAN	2
6	1952	65	350000.	LARRY CAR	4	NONE	CLEAN	2
6	1955	65	350000.	LARRY CAR	4	NONE	CLEAN	2
6	1957	65	350000.	LARRY CAR	4	NONE	CLEAN	2
7	1941	76	450000.	LARRY CAR	4	NONE	DIRTY	1
7	1945	76	450000.	LARRY CAR	4	NONE	DIRTY	1
7	1943	57	300000.	LARRY CAR	4	NONE	DIRTY	1
7	1944	57	300000.	LARRY CAR	4	NONE	DIRTY	1
7	1952	76	495000.	LARRY CAR	4	NONE	DIRTY	1
7	1962	76	495000.	LARRY CAR	4	NONE	DIRTY	1
7	1970	76	900000.	LARRY CAR	6	NONE	DIRTY	1
8	1948	74	420000.	LARRY CAR	4	NONE	DIRTY	1
9	1969	82	1170000.	LARRY CAR	6	OTHER	DIRTY	1
9	1972	82	1270000.	LARRY CAR	6	OTHER	DIRTY	2
10	1960	51	150000.	LARRY CAR	4	NONE	DIRTY	2
10	1972	65	380000.	LARRY CAR	4	NONE	DIRTY	2
10	1974	47	290000.	LARRY CAR	4	NONE	DIRTY	2
11	1947	21	80000.	LARRY CAR	3	NONE	CLEAN	1

(continued)

TABLE 8 (continued)

PLANT NO	INST. DATE	NO. OVENS	COKE CAPACITY TONS/YR	CHARGING	HEIGHT (METERS)	PUSH CONTROL	QUENCH WATER	NO. COLL. MAINS
11	1948	63	250000.	LARRY CAR	3	NONE	CLEAN	1
11	1952	29	120000.	LARRY CAR	3	NONE	CLEAN	1
12	1964	78	420000.	LARRY CAR	4	NONE	DIRTY	1
13	1962	61	460000.	LARRY CAR	4	OTHER	CLEAN	1
13	1963	61	460000.	LARRY CAR	4	OTHER	CLEAN	1
13	1963	25	200000.	LARRY CAR	4	OTHER	CLEAN	1
13	1964	45	340000.	LARRY CAR	4	OTHER	CLEAN	1
13	1972	13	100000.	LARRY CAR	4	OTHER	CLEAN	1
14	1949	49	440000.	LARRY CAR	4	OTHER	DIRTY	1
14	1953	27	240000.	LARRY CAR	4	OTHER	DIRTY	1
14	1961	61	280000.	LARRY CAR	4	OTHER	DIRTY	1
15	1957	70	430000.	LARRY CAR	4	OTHER	DIRTY	1
15	1957	78	480000.	LARRY CAR	4	OTHER	DIRTY	1
15	1978	85	1060000.	LARRY CAR	6	OTHER	DIRTY	1
16	1958	65	320000.	LARRY CAR	4	NONE	DIRTY	1
16	1956	87	460000.	LARRY CAR	4	NONE	DIRTY	1
16	1958	87	460000.	LARRY CAR	4	NONE	DIRTY	1
16	1958	87	460000.	LARRY CAR	4	NONE	DIRTY	1
16	1970	51	550000.	LARRY CAR	6	NONE	DIRTY	1
16	1974	56	910000.	PIPELINE	6	SHED	DIRTY	1
16	1978	69	1100000.	PIPELINE	6	ENCLOSED CAR	DIRTY	2
17	1953	57	300000.	LARRY CAR	4	OTHER	CLEAN	1
17	1956	50	320000.	LARRY CAR	4	NONE	CLEAN	1
17	1957	50	320000.	LARRY CAR	4	NONE	CLEAN	1
18	1953	79	470000.	LARRY CAR	4	NONE	CLEAN	1
18	1960	59	370000.	LARRY CAR	4	NONE	CLEAN	1
18	1961	59	370000.	LARRY CAR	4	NONE	CLEAN	1
18	1961	59	370000.	LARRY CAR	4	NONE	CLEAN	1
18	1961	59	370000.	LARRY CAR	4	NONE	CLEAN	1
19	1945	106	590000.	LARRY CAR	4	NONE	DIRTY	1
19	1948	106	590000.	LARRY CAR	4	NONE	DIRTY	1
19	1951	59	320000.	LARRY CAR	4	NONE	DIRTY	1
19	1976	56	1040000.	PIPELINE	6	SHED	DIRTY	1
21	1942	45	210000.	LARRY CAR	4	NONE	DIRTY	2
21	1942	45	210000.	LARRY CAR	4	NONE	DIRTY	2
21	1949	45	210000.	LARRY CAR	4	NONE	DIRTY	2
21	1953	45	210000.	LARRY CAR	4	NONE	DIRTY	2
21	1953	45	210000.	LARRY CAR	4	NONE	DIRTY	2
21	1960	45	210000.	LARRY CAR	4	NONE	DIRTY	2
21	1960	45	210000.	LARRY CAR	4	NONE	DIRTY	2
22	1944	59	220000.	LARRY CAR	4	NONE	CLEAN	1

(continued)

TABLE 8 (continued)

PLANT NO	INST. DATE	NO. OVENS	COKE CAPACITY TONS/YR	CHARGING	HEIGHT (METERS)	PUSH CONTROL	QUENCH WATER	NO. COLL. MAINS
22	1947	39	220000.	LARRY CAR	4	NONE	CLEAN	1
24	1949	40	340000.	LARRY CAR	4	NONE	DIRTY	1
24	1949	38	260000.	LARRY CAR	4	NONE	DIRTY	1
24	1950	40	340000.	LARRY CAR	4	NONE	DIRTY	1
24	1956	65	440000.	LARRY CAR	4	NONE	DIRTY	1
24	1960	59	400000.	LARRY CAR	4	NONE	DIRTY	2
25	1952	63	440000.	LARRY CAR	4	NONE	DIRTY	2
25	1952	63	440000.	LARRY CAR	4	NONE	DIRTY	2
25	1957	51	350000.	LARRY CAR	4	NONE	DIRTY	2
25	1958	51	350000.	LARRY CAR	4	NONE	DIRTY	2
25	1958	51	350000.	LARRY CAR	4	NONE	DIRTY	2
26	1976	51	350000.	LARRY CAR	4	NONE	DIRTY	2
27	1955	31	210000.	LARRY CAR	4	NONE	DIRTY	1
28	1943	75	500000.	LARRY CAR	4	SHED	CLEAN	1
29	1943	65	430000.	LARRY CAR	4	NONE	CLEAN	1
29	1952	65	390000.	LARRY CAR	4	NONE	CLEAN	1
29	1965	65	430000.	LARRY CAR	4	NONE	CLEAN	1
31	1951	87	550000.	LARRY CAR	4	NONE	DIRTY	2
31	1951	87	550000.	LARRY CAR	4	NONE	DIRTY	2
32	1924	61	270000.	LARRY CAR	4	NONE	CLEAN	2
32	1924	61	270000.	LARRY CAR	4	NONE	CLEAN	2
32	1924	61	270000.	LARRY CAR	4	NONE	CLEAN	2
32	1948	85	360000.	LARRY CAR	5	NONE	CLEAN	2
32	1950	61	270000.	LARRY CAR	4	NONE	CLEAN	2
32	1950	61	270000.	LARRY CAR	4	NONE	CLEAN	2
32	1954	64	340000.	LARRY CAR	4	NONE	CLEAN	2
32	1954	64	340000.	LARRY CAR	4	NONE	CLEAN	2
32	1954	64	340000.	LARRY CAR	4	NONE	CLEAN	2
32	1955	64	340000.	LARRY CAR	4	NONE	CLEAN	2
32	1955	64	340000.	LARRY CAR	4	NONE	CLEAN	2
32	1955	64	340000.	LARRY CAR	4	NONE	CLEAN	2
32	1957	64	340000.	LARRY CAR	4	NONE	CLEAN	2
32	1957	64	340000.	LARRY CAR	4	NONE	CLEAN	2
32	1958	64	340000.	LARRY CAR	4	NONE	CLEAN	2
32	1972	67	630000.	LARRY CAR	4	SHED	CLEAN	2
32	1973	67	690000.	LARRY CAR	4	NONE	CLEAN	2
32	1976	67	630000.	LARRY CAR	4	NONE	CLEAN	2
32	1977	67	630000.	LARRY CAR	4	NONE	CLEAN	2
33	1947	59	230000.	LARRY CAR	5	NONE	DIRTY	1
33	1947	59	230000.	LARRY CAR	5	NONE	DIRTY	1
33	1947	59	230000.	LARRY CAR	5	NONE	DIRTY	1

(continued)

TABLE 8 (continued)

PLANT NO	INST. DATE	NO. OVENS	COKE CAPACITY TONS/YR	CHARGING	HEIGHT (METERS)	PUSH CONTROL	QUENCH WATER	NO. COLL. MAINS
33	1955	59	230000.	LARRY CAR	3	NONE	DIRTY	1
33	1955	59	230000.	LARRY CAR	3	NONE	DIRTY	1
33	1956	59	230000.	LARRY CAR	3	NONE	DIRTY	1
33	1957	59	230000.	LARRY CAR	3	NONE	DIRTY	2
36	1949	77	320000.	LARRY CAR	3	NONE	DIRTY	2
36	1951	77	320000.	LARRY CAR	3	NONE	DIRTY	2
36	1951	77	320000.	LARRY CAR	3	NONE	DIRTY	1
36	1954	77	320000.	LARRY CAR	3	NONE	DIRTY	1
36	1954	77	320000.	LARRY CAR	3	NONE	DIRTY	1
36	1970	85	900000.	LARRY CAR	6	NONE	DIRTY	1
36	1975	57	930000.	HEULER	6	ENCLOSED CAR	DIRTY	2
36	1976	57	930000.	HEULER	6	ENCLOSED CAR	DIRTY	2
39	1952	77	400000.	LARRY CAR	4	NONE	CLEAN	1
39	1952	77	400000.	LARRY CAR	4	NONE	CLEAN	1
39	1958	63	400000.	LARRY CAR	4	NONE	CLEAN	1
39	1978	57	900000.	HOT L.C.	6	OTHER	CLEAN	2
40	1950	63	320000.	LARRY CAR	4	NONE	DIRTY	2
40	1950	63	320000.	LARRY CAR	4	NONE	DIRTY	2
40	1950	63	320000.	LARRY CAR	4	NONE	DIRTY	2
40	1950	63	320000.	LARRY CAR	4	NONE	DIRTY	2
41	1947	53	350000.	LARRY CAR	4	NONE	DIRTY	1
41	1947	53	350000.	LARRY CAR	4	NONE	DIRTY	1
41	1951	61	400000.	LARRY CAR	4	NONE	DIRTY	1
41	1954	41	270000.	LARRY CAR	4	NONE	DIRTY	1
41	1956	41	270000.	LARRY CAR	4	NONE	DIRTY	1
41	1973	87	1350000.	LARRY CAR	6	OTHER	CLEAN	2
42	1948	53	250000.	LARRY CAR	4	NONE	CLEAN	1
42	1952	63	300000.	LARRY CAR	4	NONE	CLEAN	1
42	1953	47	180000.	LARRY CAR	3	NONE	CLEAN	1
42	1955	47	180000.	LARRY CAR	3	NONE	CLEAN	1
42	1964	51	190000.	LARRY CAR	3	NONE	CLEAN	1
42	1976	79	800000.	LARRY CAR	6	NONE	CLEAN	2
43	1942	74	530000.	LARRY CAR	4	NONE	CLEAN	1
43	1956	19	140000.	LARRY CAR	4	NONE	CLEAN	1
44	1968	45	370000.	LARRY CAR	5	SHED	DIRTY	1
45	1954	76	460000.	LARRY CAR	4	NONE	DIRTY	2
45	1955	76	460000.	LARRY CAR	4	NONE	DIRTY	2
45	1958	76	460000.	LARRY CAR	4	NONE	DIRTY	2
46	1952	75	460000.	LARRY CAR	4	NONE	CLEAN	1
46	1956	75	460000.	LARRY CAR	4	NONE	CLEAN	1
46	1961	67	535000.	LARRY CAR	4	NONE	CLEAN	1

(continued)

TABLE 8 (continued)

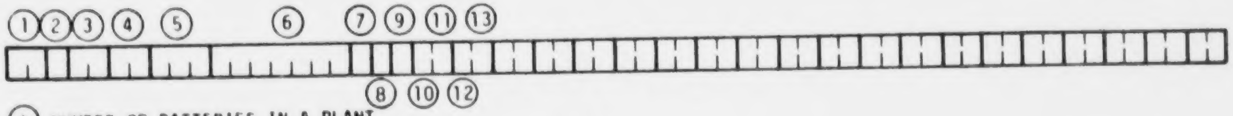
PLANT NO	INST. DATE	NO. OVENS	COKE CAPACITY TONS/YR	CHARGING	HEIGHT (METERS)	PUSH CONTROL	QUENCH WATER	NO. COLL. MAINS
48	1973	30	75000.	LARRY CAR	4	NONE	CLEAN	1
48	1973	30	73000.	LARRY CAR	4	NONE	CLEAN	1
49	1917	68	254000.	LARRY CAR	4	NONE	CLEAN	1
49	1941	76	548000.	LARRY CAR	6	NONE	CLEAN	1
49	1955	24	145000.	PIPELINE	4	NONE	CLEAN	1
50	1943	35	185000.	LARRY CAR	4	OTHER	CLEAN	1
50	1952	23	120000.	LARRY CAR	4	OTHER	CLEAN	1
65	1950	35	250000.	LARRY CAR	4	NONE	DIRTY	2
65	1952	35	250000.	LARRY CAR	4	NONE	DIRTY	2
65	1958	35	250000.	LARRY CAR	4	NONE	DIRTY	2
77	1918	24	58000.	LARRY CAR	3	NONE	DIRTY	1
77	1941	20	56000.	LARRY CAR	3	NONE	DIRTY	1
81	1962	60	326000.	LARRY CAR	4	NONE	CLEAN	1
85	1953	76	469000.	LARRY CAR	4	NONE	CLEAN	1
85	1967	70	797000.	LARRY CAR	5	NONE	CLEAN	1
86	1972	23	82000.	LARRY CAR	4	NONE	DIRTY	1
86	1972	23	82000.	LARRY CAR	4	NONE	DIRTY	1
87	1950	74	340000.	LARRY CAR	4	NONE	DIRTY	1
88	1968	70	674000.	PIPELINE	4	NONE	CLEAN	1
89	1926	40	119000.	LARRY CAR	4	NONE	CLEAN	1
89	1929	40	119000.	LARRY CAR	4	NONE	CLEAN	1
89	1941	41	121000.	LARRY CAR	4	NONE	CLEAN	1
89	1946	47	140000.	LARRY CAR	4	NONE	CLEAN	1
90	1974	40	117000.	LARRY CAR	3	OTHER	DIRTY	1
90	1974	60	175000.	LARRY CAR	3	OTHER	DIRTY	1
91	1951	51	316000.	LARRY CAR	4	NONE	CLEAN	1
91	1964	50	316000.	LARRY CAR	4	NONE	CLEAN	1
91	1967	50	316000.	LARRY CAR	4	NONE	CLEAN	1
92	1952	0	360000.	LARRY CAR	4	NONE	DIRTY	1
92	1961	93	266000.	LARRY CAR	3	SHED	CLEAN	1
93	1919	65	192000.	LARRY CAR	3	NONE	CLEAN	1
94	1958	20	44000.	LARRY CAR	3	NONE	CLEAN	1
94	1958	40	88000.	LARRY CAR	3	NONE	CLEAN	1
95	1920	17	48000.	LARRY CAR	4	NONE	DIRTY	1

(continued)

TABLE 8 (continued)

PLANT NO	INST. DATE	NO. OVENS	COKE CAPACITY TONS/YR	CHARGING	HEIGHT (METERS)	PUSH CONTROL	QUENCH WATER	NO. COLL. MAINS
95	1920	32	150000.	LARRY CAR	4	NONE	DIRTY	1
95	1925	25	79000.	LARRY CAR	4	NONE	DIRTY	1
95	1949	28	95000.	LARRY CAR	4	NONE	DIRTY	1
95	1949	30	102000.	LARRY CAR	4	NONE	DIRTY	1
95	1952	30	120000.	LARRY CAR	4	NONE	DIRTY	1
95	1969	38	153000.	LARRY CAR	4	NONE	DIRTY	1
96	1956	60	234000.	LARRY CAR	3	NONE	DIRTY	1
97	1920	60	232000.	LARRY CAR	4	NONE	CLEAN	1
97	1920	60	232000.	LARRY CAR	4	NONE	CLEAN	1
97	1950	30	116000.	LARRY CAR	4	NONE	CLEAN	1
97	1955	30	116000.	LARRY CAR	4	NONE	CLEAN	1
97	1957	60	232000.	LARRY CAR	4	NONE	CLEAN	1
98	1951	58	287000.	LARRY CAR	3	NONE	DIRTY	1
98	1952	57	282000.	LARRY CAR	3	NONE	DIRTY	1
99	1941	25	110000.	LARRY CAR	4	NONE	DIRTY	1
99	1951	29	128000.	LARRY CAR	4	NONE	DIRTY	1
99	1952	25	64000.	LARRY CAR	3	NONE	DIRTY	1
99	1968	78	500000.	PIPELINE	6	NONE	DIRTY	1

TOTAL PLANTS 59
TOTAL BATTERIES 216
TOTAL OVENS 12221.
TOTAL CAPACITY 76623.E+03



① NUMBER OF BATTERIES IN A PLANT

② TYPE OF BATTERY: 1 = EXISTING; 2 = NEW HYPOTHETICAL

③ PLANT IDENTIFICATION NUMBER

④ DATE OF INSTALLATION OR LAST MAJOR REHABILITATION

⑤ NUMBER OF OVENS IN BATTERY

⑥ COKE CAPACITY, tons/yr

⑦ CHARGING METHOD: 1 = LARRY CAR; 2 = PIPELINE; 3 = REDLER; 4 = HOT LARRY CAR

⑧ OVEN HEIGHT, m

⑨ NUMBER OF COLLECTING MAINS: 1 OR 2

⑩ BASELINE CONTROL LEVEL FOR SOURCE 1

⑪ EXISTING CONTROL LEVEL FOR SOURCE 1

⑫ BASELINE CONTROL LEVEL FOR SOURCE 2

⑬ EXISTING CONTROL LEVEL FOR SOURCE 2

REMAINDER OF COLUMNS SET IN SIMILAR FASHION FOR SOURCES 3 THROUGH 20

Figure 18. Battery data card format.

TABLE 9. PLANT ID CODES

Plant ID[a]	Company
01	Keystone Coke, Conshohocken, Pa.
02	Armco, Middletown, Ohio
04	Armco, Houston, Tex.
05	Bethlehem, Bethlehem, Pa.
06	Bethlehem, Sparrows Point, Md.
07	Bethlehem, Lackawanna, N.Y.
08	Bethlehem, Johnstown, Pa.
09	Bethlehem, Burns Harbor, Ind.
10	CFI, Pueblo, Colo.
11	Crucible, Midland, Pa.
12	Empire Detroit, Portsmouth, Ohio
13	Ford, Rouge Works, Detroit, Mich.
14	Granite City, Granite City, Ill.
15	Great Lakes Steel, Detroit, Mich.
16	Inland, East Chicago, Ind.
17	Interlake, South Chicago, Ill.
18	J & L, Pittsburgh, Pa.
19	J & L, Aliquippa, Pa.
21	Kaiser, Fontana, Calif.
22	Lonestar Steel, Texas
24	Republic, Mahoning Valley Dist., Ohio
25	Republic, Cleveland, Ohio
27	Republic, Central Alloy Dist., Ohio
28	Republic, South Chicago, Ill.
29	Republic, Gulfsteel, Ala.
31	USS, Fairless Hills, Pa.
32	USS, Homestead Clairton, Pa.
33	USS, Lorain, Cuyahoga, Ohio
36	USS, Gary, Ind.
39	USS, Fairfield, Ala.
40	USS, Geneva, Utah

(continued)

TABLE 9 (continued)

Plant ID[a]	Company
41	Weirton Steel, Weirton, W. Va.
42	Wheeling Pitt, Steubenville, Ohio
43	Wheeling Pitt, Monesson, Pa.
44	Wisconsin, South Chicago, Ill.
45	YST, Campbell, Youngstown, Ohio
46	YST, East Chicago, Ind.
48	Indiana Gas, Terre Haute, Ind.
49	Allied, Ironton, Ohio
50	Koppers, Erie, Pa.
65	Shenango, Neville Island, Pa.
77	Chatanooga Coke & Chem., Tenn.
81	Allied, Buffalo, N.Y.
85	Allied, Ashland, Ky.
86	Diamond Shamrock, Painesville, Ohio
87	Eastern Fuel Assoc. Philadelphia, Pa.
88	Allied Chemical, Detroit, Mich.
89	Citizens Gas, Indianapolis, Ind.
90	Milwaukee Solvay, Milwaukee, Wis.
91	Donnar Hanna, Buffalo, N.Y.
92	Missouri Coke, St. Louis, Mo.
93	Koppers, St. Paul, Minn.
94	Empire Coke, Holt, Ala.
95	Koppers, Bessemer, Ala.
96	Sharon, Fairmont, W. Va.
97	Jim Walter, Birmingham, Ala.
98	USS Duluth, Minn.
99	ABC, Tarrant, Ala.

[a] Plant ID numbers are not sequential.

battery stacks has not been considered. Also, the number of spare hot cars required in a multibattery plant is less in proportion to capacity than the number at an isolated plant having one battery. Such site-specifics are not considered in this project.

New Versus Existing Batteries

To evaluate projected growth (or decline) in the industry, the user may add battery data cards corresponding to the projected growth, or delete the battery cards for projected retirements.

New battery cards must be filled out even though the data may be speculative. It is not sufficient just to enter simply 10 percent growth; the user must decide, for example, that there will be 10 new batteries by 1985, that they will be 60-oven batteries 6 meters high and that they will be equipped with some specific controls. Only if specific plans for a given plant are known is the plant ID entered. In the case of retirements the user simply removes the battery card from the card deck.

The primary distinction between "new" and "existing" in the model is the use of new or retrofit cost functions.

Existing Installed Equipment

Columns 21 to 60 of the battery data card (Figure 18) are 20 two-digit fields corresponding to the twenty sources considered. Only 16 are now used. The code numbers to be entered in these fields correspond to the control option codes. The first column of each two digit field contains the desired baseline code and the second column contains the existing control code.

Because the control level (control efficiency and exact control equipment) of a given plant may not be the same as those designated in the options used, the user must be careful to select the code for the control option that most closely corresponds to the existing equipment or control program.

In the computer program, the code is used for one of two purposes:

1. To correct total industry cost (or total cost for any given industry subset) by eliminating the cost of a control option for those plants where the option is already in use.

2. To allow the use of a control baseline (e.g., SIP) whereby only costs above this baseline are considered. The same baseline can be used for every battery. A single card for all batteries can be used to avoid having to enter the same codes on each of the more than 200 battery cards. This card is designated as Control Card 3, described in Section 2.

As an example of the first purpose, assume Battery 1 has already installed a new larry car for stage charging and has good stage charging practice. The card for this battery would then contain a Code 3 in the charging columns (Column 22). Consequently, in the program to determine the cost of charging controls for this plant, the only costs calculated will be those for controls achieving control levels greater than level 3. "Tear-out" costs (i.e., for removal of existing controls) are not considered in the present model.

A more complicated example arises when the existing controls achieve an efficiency close to that described in the options but are represented by different hardware. If a battery already has a shed and scrubber, for example, it is probably better to consider this comparable in achieving a given level of control rather than equivalent to the specific hardware configuration. For this reason, the control options are ordered according to degree of efficiency. This permits the user to select the option that achieves the highest level he considers appropriate. The computer will disregard the cost of all options equal to or less than the option selected for the given battery.

The approach in the second purpose is similar, but the concept is different. In this case the user establishes a baseline of control below which control costs are not considered whether installed or not. For example, if the baseline for charging control is modified larry cars for stage charging, no costs will be calculated for control options achieving control levels below those of larry car modification. The battery card in this case would contain a Code 2 in the charging columns (Column 21). In the extreme, if the highest control option were selected as the baseline for every source, no costs would be calculated. If the user wanted costs for inspection only, they could be obtained by making a computer run with "uncontrolled" as the baseline.

REFERENCES FOR SECTION 6

1. Industry Response to Section 308 Effluent Guidelines Questionnaires 1976-1977.

2. Pictrucha, W.E., and R.L. Deily. Steel Industry in Brief: Databook USA, 1977. Institute for Iron and Steel Industries, Green Brook, New Jersey.

3. Iron & Steel Works Directory of the United States and Canada. American Iron and Steel Institute. 1977.

4. Air and Water Compliance Summary for the Iron and Steel Industry. U.S. Environmental Protection Agency, Office of Enforcement. October 20, 1977.

5. World Steel Industry Data Handbook, Vol. 1. The United States, 33 Magazine 1978, McGraw Hill, 1221 Avenue of the Americas, New York, New York 10020.

6. Kulujian, N.J. By-Product Coke Battery Compliance Evaluation. Prepared for U.S. Environmental Protection Agency, DSSE by PEDCo Environmental, Inc. June 1975. EPA Contract No. 68-02-1321, Task 13.

SECTION 7

MODEL FORMULATION

The first step in the model is the calculation of total industry control costs. In the discussion of this calculation, mathematical nomenclature has been defined as follows:

i = the emission source $(i = 1 \ldots I)$
j = the pollutant $(j = 1 \ldots J)$
k = the control technology $(k = 1 \ldots K)$
n = the specific battery $(n = 1 \ldots N)$
E = the annual emissions, in tons/year
C = the annualized cost (or capital cost)
e_{ijk} = the control efficiency
X_n = the capacity of battery n in tons coke/year
U_{ij} = the uncontrolled emission factor in lbs/ton coal

Note that for some sources such as coke handling, X_n actually represents capacity for all batteries in a given plant.

Then C_{ijkn} represents a specific dollar value calculated from the general cost function:

$$C_{ijkn} = A_{ijk} X_n^{B_{ijk}}$$

where A = y intercept, B = slope

Note that $C_{i1kn} = C_{i2kn} = C_{i4kn}$,

i.e., the cost of a specific control system does not vary by pollutant.

Similarly, $E_{ijkn} = [\frac{(100 - e_{ijk})}{100} (U_{ij}) (X_n/.7)] / 2000$

but, $E_{i1kn} \neq E_{i2kn} \neq E_{i3kn} \neq E_{i4kn}$

The C and E matrices are calculated from the input datasets. Note that k = 1 will represent no additional control. Therefore, C_{ij1n} = zero by definition and

$$E_{ij1n} = [(U_{ij})(X_n/.7)] \div 2000$$

The total emission restriction (Mode 2) is entered as an overall percent efficiency, represented by R_j. This will be converted to ρ_j, an annual quantity, by the equation:

$$\rho_j = (1-\frac{R_j}{100})\ (\sum_{n=1}^{N} \sum_{i=1}^{I} E_{ijn},\ k = 1)$$

The total cost restriction (Mode 3) will be entered as a total dollar amount, T.

Finally, note that not all i exist for every n. Therefore, the C and E matrices are not full.

The next step is to compress the total C and E matrices to a total industry basis, i.e., eliminate the n dimension. Let C' and E' represent the total industry:

$$C'_{ijk} = \sum_{n=1}^{N} C_{ijkn}$$

Again noting that $C'_{i1k} = C'_{i2k} = C'_{i3k} = C'_{i4k}$

Similarly,

$$E'_{ijk} = \sum_{n=1}^{N} E_{ijkn}$$

and $E'_{ijk} \neq E'_{i2k} \neq E'_{i3k} = E'_{i4k}$

Furthermore, E' can be treated as four separate matrices, E'_{ik} for j = 1, E'_{ik} for j = 2, etc.

The data is now reduced to two simple matrices:

C_{ik} and E_{ik} for each j

To find the optimum combination of controls, consider Mode 2, the restriction being total emissions, ρ_j, and the objective being to find lowest cost. Another matrix, Y, must now be introduced. The values of Y will be either one or zero. A one will indicate that a control option, k, is selected and a zero will indicate that the control option is not selected. The Y matrix is a mathematical device to solve the optimization and has no significance from an engineering standpoint. For example,

let $Y_{ik} = Y_{14} = 1$

this means Control Option 4 on Emission Source 1 is part of the optimum solution.

If this is so, then by definition, all other Y's for source 1 are zero:

$$Y_{11} = Y_{12} = Y_{13} = Y_{15} = Y_{16} = Y_{1k} = 0$$

That is, a source can only be controlled by one option at a time.

The statement of the problem in matrix form is therefore:

Minimize ΣCY for a given j
subject to $\Sigma Y = 1$ for all i
and $\Sigma EY \leqslant \rho$ for a given j
and $Y \geqslant 0$ for all i

In expanded form:

$$\begin{aligned} \text{minimize } & C_{11}Y_{11} + C_{12}Y_{12} + \;\ldots\ldots\; C_{1k}Y_{1k} \\ & + C_{21}Y_{21} + C_{21}Y_{21} + \;\ldots\ldots\; C_{2k}Y_{2k} \\ & + \;\ldots\ldots\ldots\ldots\ldots\ldots\; C_{ik}Y_{ik} \end{aligned}$$

$$\begin{aligned} \text{subject to } & Y_{11} + Y_{12} + Y_{13} + \;\ldots\ldots\; Y_{1k} = 1 \\ & Y_{21} + Y_{22} + Y_{23} + \;\ldots\ldots\; Y_{2k} = 1, \text{ etc. for each } i \end{aligned}$$

$$\begin{aligned} \text{and: } & E_{11}Y_{11} + E_{12}Y_{12} + \;\ldots\ldots\; E_{1k}Y_{1k} \\ & + E_{21}Y_{21} + E_{21}Y_{21} + \;\ldots\ldots\; E_{2k}Y_{2k} \\ & + \;\ldots\ldots\ldots\ldots\ldots\ldots\; E_{ik}Y_{ik} \leqslant \rho_j \end{aligned}$$

and $Y_{ik} \geqslant 0$ for every i and k

The optimal solution to this problem will be determination of the Y matrix. The Y matrix in turn will define a k value for each i (i.e., a control option for each emission source that will result in the overall minimum cost for meeting a total emission restriction). Note that any given k may equal 1, i.e., no control. In general, the program will select those alternatives which reduce emissions the most and cost the least.

After the optimum solution is found, the Y matrix will be superimposed onto the E matrices for the other pollutants to determine the emissions of the pollutants that were not restricted. To the optimum totals the program will add the costs and emissions for those sources previously excluded from the optimization (by using the No. 2 cards described in Section 1) to get total industry costs and emissions.

The statement for Mode 3 is very similar:

Minimize ΣEY
subject to: $\Sigma CY \leq T$
and $\Sigma Y=1$
and $Y \geq 0$

The same approach as described above is used in this case also. Operation of the model in Modes 2 and 3 is identical regardless of whether annualized cost or capital cost is the subject of optimization.

The greatest value of the model is its ability to supply rapid answers to "what if" questions. The model has great flexibility, and its user can easily examine its sensitivity to variations in the emission factors and control costs by simply changing the input data.

Controls for any given emission source can be fixed at a predetermined level and the source can thus be removed from the optimization procedure. The battery data base can be set up to represent all batteries or any subset of batteries. For example, furnace coke producers can be separated from foundry coke producers.

SECTION 8

RESULTS

The function of the model is to calculate emissions and emission control costs and to select a set of controls that will meet a given emission restriction at the lowest cost. Conceptually, this is as if the "bubble concept" were applied to all the coke plants in the United States. Section 2 describes the many variations of the basic scheme.

An example best illustrates the logic of the model. The data base for this example consists of the 216 coke oven batteries presented in Section 6, the uncontrolled emission factors presented in Table 1, and the control options and their efficiencies presented in Table 2. Annualized and capital cost functions associated with the control options are shown in Appendix A.

Figure 19 is a graphic presentation of the capital cost functions for the three control options applicable to Source 1, wet coal charging. These values are based on tons of coke capacity for a 60-oven battery. An increase in the number of ovens would increase the cost because certain elements of the capital cost (e.g., steam lines and number of standpipes) are directly proportional to the number of ovens. Every cost function represented in Appendix A could be plotted as shown on Figure 19.

Figure 20 shows the annualized cost per pound of particulate removed for the same three options. The spacing of the curves is related to both the relative costs of the options and the relative efficiencies. Although Option 3 is more costly than Option 2, the curves are very close because the efficiency of

Option 3 is 99 percent compared with only 80 percent for Option 2. The 99.5 percent efficiency of Option 4, on the other hand, represents an improvement of only 0.5 percent over Option 3, but the cost is much higher. Each option for each source could be analyzed in a similar manner.

Table 10 presents the capital and annualized cost matrix calculated for the present data base. Table 11 presents the uncontrolled emissions matrix. These matrices and the appropriate control efficiencies could be used to generate curves like those in Figures 19 and 20 for each source.

The function of the optimization model is to analyze all such curves and find the lowest cost combinations. In this section, the examples deal with minimizing annualized cost, but the approach is identical for capital cost. Table 12 is the model output for a case of no control on any source. This provides a convenient frame of reference for uncontrolled emission quantities. The table shows that pushing is the largest single source of uncontrolled particulate emissions, although the total of quenching (with clean water and with dirty water) is slightly larger. Charging is by far the largest single source of both BSO and benzene emissions.

Table 13 is the model output to meet a restriction calling for an overall particulate control at least 95 percent efficiency, which requires the highest possible control level on every source except dry coal charging and the byproducts plant. The latter two are excluded from the solution by the model because their contributions to particulate emissions are very low; in fact, particulate emissions from the byproducts plant are zero. Total annualized costs for the industry are $1,396,000,000 and total capital costs (retrofit) are $2,887,000,000. It should be noted that the model seeks to minimize annualized costs in the examples presented in this section. In this example the costs do not take into account any control that may already exist, as indicated by the baseline notation in the tables. That is, the costs are theoretical costs based on no controls on any battery.

TABLE 10. TOTAL CAPITAL AND ANNUALIZED COSTS FOR CONTROL OPTIONS (in millions of dollars)

Source/control option	Total capital cost	Total annualized cost
Wet coal charging		
Modified larry car	91	124
New larry car	304	165
New larry car and second main	649	254
Coke pushing		
Controlled coking	0	993
Shed + ESP with 95% eff.	905	295
Shed + scrubber with 95% eff.	1277	489
Enclosed hot car	1164	314
Shed + ESP with 99% eff.	973	307
Shed + scrubber with 99% eff.	1330	538
Quenching, clean water		
Conventional baffles	7	2.4
Diverted flow baffles	53	14
Dry quenching	424	111
Doors		
Cleaning and maintenance	0	174
High pressure water cleaning	90	189
Hoods + scrubber with 95% eff.	386	464
Hoods + scrubber with 98% eff.	439	481
Topside		
Luting and cleaning	0	57
Luting, cleaning, and maintenance	0	109
New lids	22	63
Combustion stack, old		
Oven patching	0	89
Dry ESP with 90% eff.	411	153
Dry ESP with 98% eff.	544	176
Fabric filter with 98% eff.	325	112

(continued)

TABLE 10 (continued)

Source/control option	Total capital cost	Total annualized cost
Coke handling		
Enclosures + fabric filter	40	17
Coal preheater		
Scrubber with 95% eff.	11.7	9
Dry ESP with 95% eff.	10.5	5
Scrubber with 98% eff.	12.1	10
Dry ESP with 99% eff.	12.7	6
Coal preparation		
Enclosures + fabric filter	29	13
Coal storage		
Water spray truck	17	8
Unloading sprays + spray truck	30	11
Coal pile sprays	148	69
Pipeline charging		
Operating and maintenance program	0	3
Redler charging		
Operating and maintenance program	0	0.7
Hot larry car charging		
Operating and maintenance program	0	0.3
Byproduct plant		
Maintenance program	0	17
Combustion stack, new		
Oven patching	0	20
Quenching, dirty water		
Conventional baffles	9	3.5
Clean water + conventional baffles	273	168
Clean water + diverted flow baffles	341	184
Dry quenching	800	251

TABLE 11. TOTAL UNCONTROLLED EMISSIONS
(tons/year)

Emission source	Pollutant			
	Particulates	BSO	BaP	Benzene
Wet coal charging	49,600	54,600	100	24,800
Coke pushing	109,500	4,400	2	330
Quenching with clean water	41,000	41	3	1
Doors	21,900	27,400	164	1,100
Topside	10,900	13,700	55	274
Combustion stack, old	43,800	225	2	0
Coke handling	54,700	0	0	0
Coal preheater	35,900	5,400	2	71
Coal preparation	27,400	0	0	0
Coal storage	8,200	0	0	0
Pipeline charging	50	60	a	25
Redler charging	13	8	a	7
Hot larry car charging	11	12	a	5
Byproducts plant	0	16,400	0	10,900
Combustion stack, new	2,200	10	a	0
Quenching with dirty water	97,900	196	10	8

[a] Less than one ton per year.

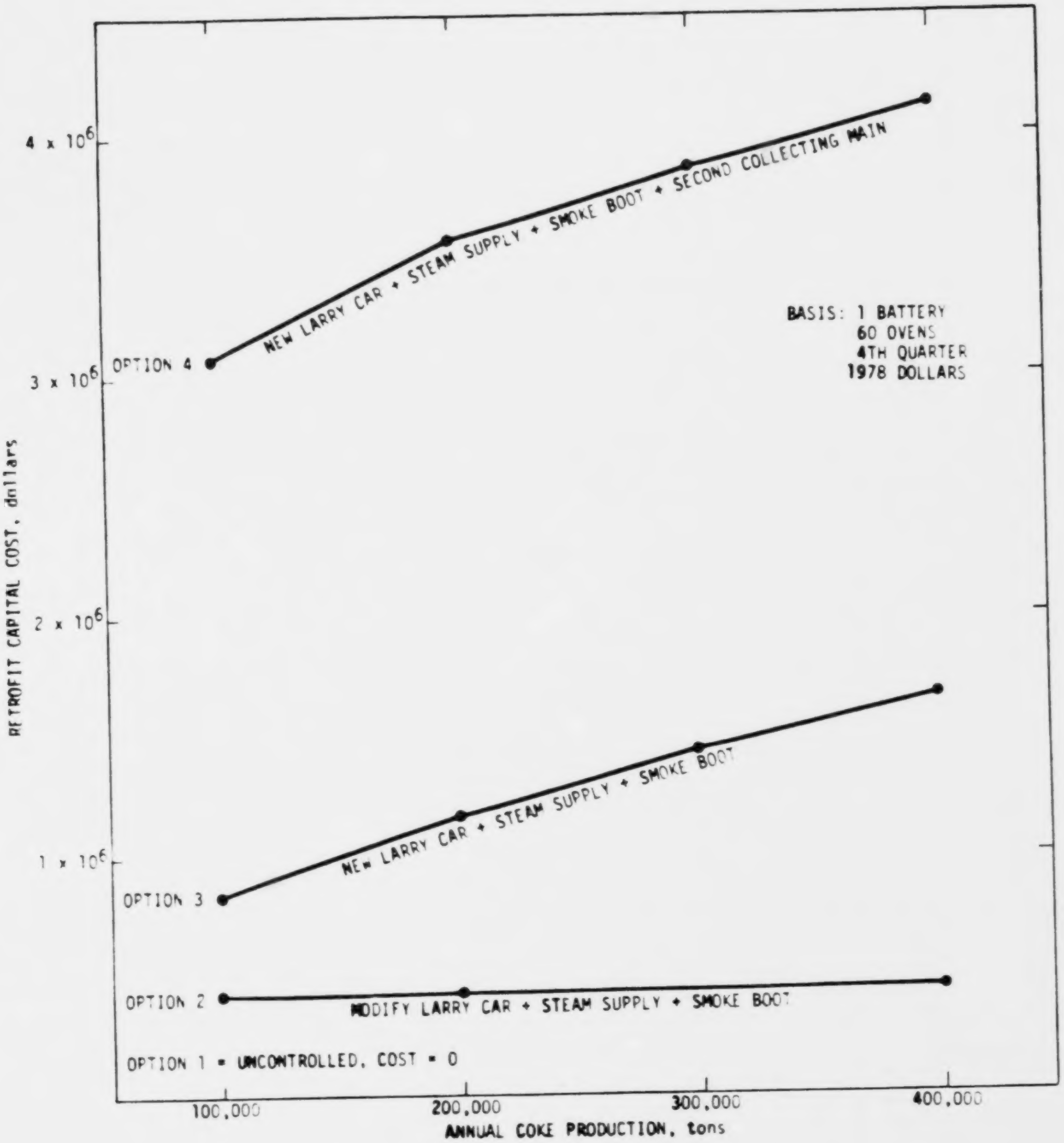


Figure 19. Capital cost of control options for wet coal charging.

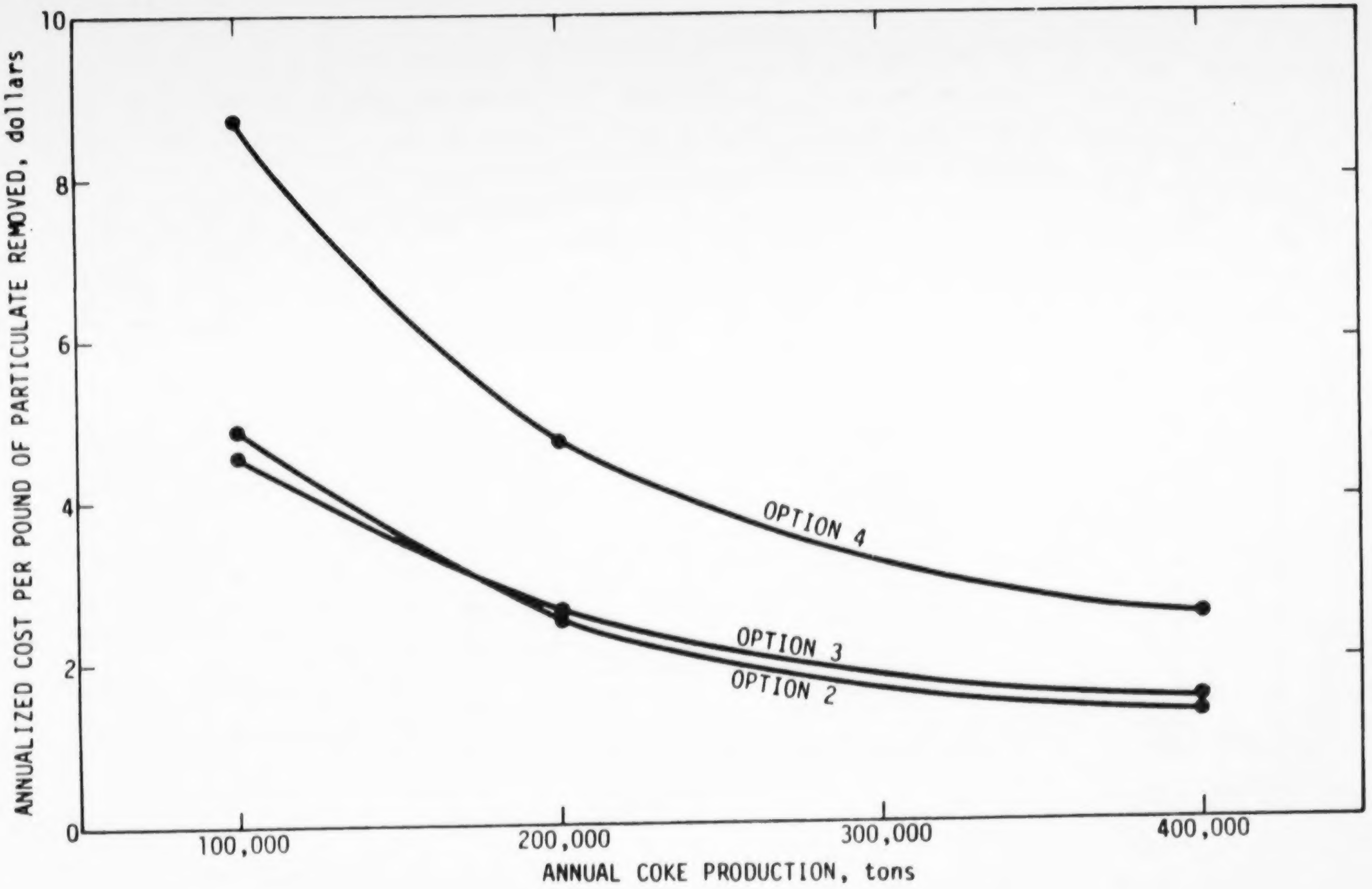


Figure 20. Cost per pound of particulate removal for control options for wet coal charging.

TABLE 12. MODEL OUTPUT FOR BASELINE OF NO CONTROL

```
                         COKE OVEN OPTIMIZATION

  OBJECTIVE: MINIMUM ANNUALIZED COST RESTRICTION:    .0%  OVERALL EFFICIENCY  POLLUTANT:BSO         BASE YEAR 1979
  BASELINE: ASSUMING NO SIP OR EXISTING CONTROLS

                                      CONTROLLED EMISSIONS                                               CONTROLLED COST
                                 (LBS/TON COAL)             (TONS/YEAR)                                   (MILLION DOLLARS)

        SOURCE                TSP    BSO    BAP    BEN    TSP    BSO    BAP    BEN   CONTROL SCHEME        CAPITAL  ANNUALIZED
 LARRY CAR CHARGING         *1.00 1.1000  .0020  .5000  49635  54599     99  24817 UNCONTROLLED             .0         .0
 COKE PUSHING               *2.00  .0800  .0000  .0060 109463   4378      2    328 UNCONTROLLED             .0         .0
 QUENCHING - CLEAN WATER    *1.70  .0017  .0001  .0000  41049     41      3      0 UNCONTROLLED             .0         .0
 DOORS                      * .40  .5000  .0030  .0200  21892  27365    164   1094 UNCONTROLLED             .0         .0
 TOPSIDE                    * .20  .2500  .0010  .0050  10946  13682     54    273 UNCONTROLLED             .0         .0
 COMBUSTION STACK - OLD     *1.30  .0060  .0001  .0000  48840    225      2      0 UNCONTROLLED             .0         .0
 COKE HANDLING              *1.00  .0000  .0000  .0000  54731      0      0      0 UNCONTROLLED             .0         .0
 COAL PREHEATER             *7.05 1.0500  .0004  .0140  35925   5350      1     71 UNCONTROLLED             .0         .0
 COAL PREPARATION           * .50  .0000  .0000  .0000  27365      0      0      0 UNCONTROLLED             .0         .0
 COAL STORAGE YARD          * .15  .0000  .0000  .0000   8209      0      0      0 UNCONTROLLED             .0         .0
 PIPELINE CHARGING          * .02  .0190  .0000  .0080     49     59      0     24 UNCONTROLLED             .0         .0
 REDLER CHARGING            * .01  .0060  .0000  .0049     13      7      0      6 UNCONTROLLED             .0         .0
 HOT LARRY CAR CHARGING     * .02  .0190  .0000  .0080     10     12      0      5 UNCONTROLLED             .0         .0
 BY-PRODUCTS PLANT          * .00  .3000  .0000  .2000      0  16419      0  10946 UNCONTROLLED             .0         .0
 COMBUSTION STACK - NEW     * .13  .0006  .0000  .0000   2231     10      0      0 UNCONTROLLED             .0         .0
 QUENCHING - DIRTY WATER    *3.20  .0064  .0003  .0003  97871    195      9      7 UNCONTROLLED             .0         .0


  TOTAL UNC.                  9.3  2.235   .006   .686 508238 122349    337  37577
  EXISTING CONTROL                                     388402  76172    254  17656                        297.5      197.1
  EXISTING EFFICIENCY                                    23.6   37.7   24.6   53.0
  BASELINE CONTROL                                     508237 122348    337  37577                          .0         .0
  BASELINE EFFICIENCY                                      .0     .0     .0     .0
  TOTAL CONTROLLED                                     508238 122349    337  37577                          .0         .0
  PERCENT CONTROLLED                                       .0     .0     .0     .0

              EXISTING                                            NEW
       TOTAL BATTERIES 216    TOTAL OVENS 12221          TOTAL BATTERIES   0    TOTAL OVENS     0

       TOTAL CAPACITY  109494267  TONS COAL              TOTAL CAPACITY          0  TONS COAL

                        76623000  TONS COKE                                      0  TONS COKE

       * NOT IN OPTIMIZATION
```

TABLE 13. MODEL OUTPUT FOR 95 PERCENT OVERALL PARTICULATE REDUCTION

```
                         COKE OVEN OPTIMIZATION

OBJECTIVE: MINIMUM ANNUALIZED COST RESTRICTION:  95.0%  OVERALL EFFICIENCY  POLLUTANT:TSP          BASE YEAR 1979
BASELINE: ASSUMING NO SIP OR EXISTING CONTROLS

                                       CONTROLLED EMISSIONS                                                       CONTROLLED COST
                                 (LBS/TON COAL)             (TONS/YEAR)                                          (MILLION DOLLARS)

      SOURCE                 TSP    BSO    BAP    BEN    TSP    BSO    BAP    BEN   CONTROL SCHEME                   CAPITAL  ANNUALIZED
LARRY CAR CHARGING           .01  .0055  .0000  .0025    248    272      0    124 NEW CAR, SECOND MAIN              649.3     253.6
COKE PUSHING               * .22  .0440  .0000  .0033  11931   2408      1    180 ENCLOSED HOT CAR                     .0        .0
QUENCHING - CLEAN WATER      .03  .0000  .0000  .0000    820      0      0      0 DRY QUENCHING                     423.9     111.4
DOORS                        .03  .0810  .0005  .0056   1466   4433     26    306 DOOR HOOD, SCRUBBER 98%           439.1     481.1
TOPSIDE                      .01  .0075  .0000  .0002    328    410      1      8 NEW LIDS & CASTINGS                21.8      63.0
COMBUSTION STACK - OLD       .03  .0030  .0000  .0000    976    112      1      0 BAGHOUSE, 98%                     323.2     111.6
COKE HANDLING                .11  .0000  .0000  .0000   5965      0      0      0 ENCLOSURES + BAGHOUSE              40.0      16.5
COAL PREHEATER               .07  .5250  .0002  .0070    359   2675      0     35 ESP 99%                            12.7       5.8
COAL PREPARATION             .02  .0000  .0000  .0000    820      0      0      0 ENCLOSURE + BAGHOUSE - 99%         29.1      12.7
COAL STORAGE YARD            .02  .0000  .0000  .0000    820      0      0      0 COAL PILE SPRAYS                  147.9      68.6
PIPELINE CHARGING            .02  .0190  .0000  .0080     49     59      0     24 UNCONTROLLED                         .0        .0
REDLER CHARGING              .01  .0060  .0000  .0049     13      7      0      6 UNCONTROLLED                         .0        .0
HOT LARRY CAR CHARGING       .02  .0190  .0000  .0080     10     12      0      5 UNCONTROLLED                         .0        .0
BY-PRODUCTS PLANT            .00  .3000  .0000  .2000      0  16419      0  10946 UNCONTROLLED                         .0        .0
COMBUSTION STACK - NEW       .03  .0001  .0000  .0000    446      2      0      0 OVEN PATCHING                        .0      20.1
QUENCHING - DIRTY WATER      .03  .0001  .0000  .0000    978      1      0      0 DRY QUENCHING                     799.5     251.4


 TOTAL UNC.                  9.3  2.235   .006   .686 508238 122349    337  37577
 EXISTING CONTROL                                     388402  76172    254  17656                                   297.5     197.1
 EXISTING EFFICIENCY                                    23.6   37.7   24.6   53.0
 BASELINE CONTROL                                     508237 122348    337  37577                                      .0        .0
 BASELINE EFFICIENCY                                      .0     .0     .0     .0
 TOTAL CONTROLLED                                      25238  26816     32  11638                                  2886.6    1395.8
 PERCENT CONTROLLED                                     95.0   78.1   90.5   69.0

          EXISTING                                            NEW
  TOTAL BATTERIES 216    TOTAL OVENS 12221        TOTAL BATTERIES  0    TOTAL OVENS     0

  TOTAL CAPACITY  109494267  TONS COAL            TOTAL CAPACITY          0  TONS COAL

                   76623000  TONS COKE                                    0  TONS COKE

  * NOT IN OPTIMIZATION
```

When dry quenching is selected as the control for quenching emissions, no cost is assigned to the enclosed car option for pushing emissions because the equivalent of an enclosed car is included in the cost of the dry quenching system. For small batteries (less than 100,000 tons of coke per year) further examination of the cost functions for dry quenching is required because they are not necessarily applicable in this small size range. If a shed is selected as the control option for pushing emissions, the cost of door hoods is reduced to the extent that they are not used on the coke-side doors. Otherwise there would be a double accounting of the control cost for coke-side doors.

Cost is overstated when the options selected include a scrubber and wastewater recirculation. This occurs because each battery is treated independently. An example would be a plant with four batteries, on which both door hoods and a wastewater recirculation system are provided for each battery. In such a scheme it is likely that one common water system could be installed to serve all four batteries for less than the cost of four separate water systems. Similarly, if a shed and scrubber were installed for control of pushing emissions and coke-side door emissions and a hood system was installed for pusher-side doors, the water system (and perhaps the scrubber itself) could be designed to handle both sources.

Although the existing model could be modified to address these issues, specific assumptions would be required.

Tables 14, 15, and 16 represent the model output for the same kind of problem except that the control efficiency restrictions are set at 80, 85, and 90 percent, respectively. In these cases, certain sources can use lower-level control schemes, and the total cost is decreased. Figure 21 shows total cost as a function of efficiency, based on the results shown on Tables 13 through 16.

TABLE 14. MODEL OUTPUT FOR 80 PERCENT OVERALL PARTICULATE REDUCTION

COKE OVEN OPTIMIZATION

OBJECTIVE: MINIMUM ANNUALIZED COST RESTRICTION: 80.0% OVERALL EFFICIENCY POLLUTANT:TSP BASE YEAR 1979
BASELINE: ASSUMING NO SIP OR EXISTING CONTROLS

	CONTROLLED EMISSIONS (LBS/TON COAL)				CONTROLLED EMISSIONS (TONS/YEAR)					CONTROLLED COST (MILLION DOLLARS)	
SOURCE	TSP	BSO	BAP	BEN	TSP	BSO	BAP	BEN	CONTROL SCHEME	CAPITAL	ANNUALIZED
LARRY CAR CHARGING	.20	.2200	.0004	.1000	9927	10919	19	4963	MODIFIED CAR, STEAM, BOOT	90.6	124.0
COKE PUSHING	.22	.0440	.0000	.0033	11931	2408	1	180	SHED + ESP 99%	972.9	307.0
QUENCHING - CLEAN WATER	.17	.0002	.0000	.0000	4104	4	0	0	DIVERTED FLOW BAFFLES	58.0	14.0
DOORS	.40	.5000	.0030	.0200	21892	27365	164	1094	UNCONTROLLED	.0	.0
TOPSIDE	.20	.2500	.0010	.0050	10946	13682	54	273	UNCONTROLLED	.0	.0
COMBUSTION STACK - OLD	.03	.0030	.0000	.0000	976	112	1	0	BAGHOUSE, 98%	323.2	111.6
COKE HANDLING	.11	.0000	.0000	.0000	5965	0	0	0	ENCLOSURES + BAGHOUSE	40.0	16.5
COAL PREHEATER	.07	.5250	.0002	.0070	359	2675	0	35	ESP 99%	12.7	5.8
COAL PREPARATION	.02	.0000	.0000	.0000	820	0	0	0	ENCLOSURE + BAGHOUSE - 99%	29.1	12.7
COAL STORAGE YARD	.04	.0000	.0000	.0000	2052	0	0	0	UNLOAD SPRAYS + WATER TRUCK	29.6	11.4
PIPELINE CHARGING	.02	.0190	.0000	.0080	49	59	0	24	UNCONTROLLED	.0	.0
REDLER CHARGING	.01	.0060	.0000	.0049	13	7	0	6	UNCONTROLLED	.0	.0
HOT LARRY CAR CHARGING	.02	.0190	.0000	.0080	10	12	0	5	UNCONTROLLED	.0	.0
BY-PRODUCTS PLANT	.00	.3000	.0000	.2000	0	16419	0	10946	UNCONTROLLED	.0	.0
COMBUSTION STACK - NEW	.13	.0006	.0000	.0000	2231	10	0	0	UNCONTROLLED	.0	.0
QUENCHING - DIRTY WATER	.96	.0019	.0001	.0003	29361	58	2	7	BAFFLES	9.3	3.5
TOTAL UNC.	9.3	2.235	.006	.686	508238	122349	337	37577			
EXISTING CONTROL					388402	76172	254	17656		297.5	197.1
EXISTING EFFICIENCY					23.6	37.7	24.6	53.0			
BASELINE CONTROL					508237	122348	337	37577		.0	.0
BASELINE EFFICIENCY					.0	.0	.0	.0			
TOTAL CONTROLLED					100644	73737	245	17539		1565.3	606.5
PERCENT CONTROLLED					80.2	39.7	27.3	53.3			

EXISTING		NEW	
TOTAL BATTERIES 216	TOTAL OVENS 12221	TOTAL BATTERIES 0	TOTAL OVENS 0
TOTAL CAPACITY 109494267 TONS COAL		TOTAL CAPACITY 0 TONS COAL	
76623000 TONS COKE		0 TONS COKE	

* NOT IN OPTIMIZATION

TABLE 15. MODEL OUTPUT FOR 85 PERCENT OVERALL PARTICULATE REDUCTION

```
          COKE OVEN OPTIMIZATION

     OBJECTIVE: MINIMUM ANNUALIZED COST RESTRICTION:  85.0%  OVERALL EFFICIENCY  POLLUTANT:TSP         BASE YEAR 1979
     BASELINE: ASSUMING NO SIP OR EXISTING CONTROLS


                                         CONTROLLED EMISSIONS                                           CONTROLLED COST
                                   (LBS/TON COAL)             (TONS/YEAR)                               (MILLION DOLLARS)

      SOURCE               TSP    BSO    BAP    BEN    TSP    BSO   BAP   BEN    CONTROL SCHEME         CAPITAL  ANNUALIZED
 LARRY CAR CHARGING        .20  .2200  .0004  .1000   9927  10919    19  4963 MODIFIED CAR, STEAM, BOOT      90.6      124.0
 COKE PUSHING              .22  .0440  .0000  .0033  11931   2408     1   180 SHED + ESP 99%                972.9      307.0
 QUENCHING - CLEAN WATER   .17  .0002  .0000  .0000   4104      4     0     0 DIVERTED FLOW BAFFLES          58.0       14.0
 DOORS                     .40  .5000  .0030  .0200  21892  27365   164  1094 UNCONTROLLED                     .0         .0
 TOPSIDE                   .20  .2500  .0010  .0050  10946  13682    54   273 UNCONTROLLED                     .0         .0
 COMBUSTION STACK - OLD    .03  .0030  .0000  .0000    976    112     1     0 BAGHOUSE, 98%                 323.2      111.6
 COKE HANDLING             .11  .0000  .0000  .0000   5965      0     0     0 ENCLOSURES + BAGHOUSE          40.0       16.5
 COAL PREHEATER            .07  .5250  .0002  .0070    359   2675     0    35 ESP 99%                        12.7        5.8
 COAL PREPARATION          .02  .0000  .0000  .0000    820      0     0     0 ENCLOSURE + BAGHOUSE - 99%     29.1       12.7
 COAL STORAGE YARD         .04  .0000  .0000  .0000   2052      0     0     0 UNLOAD SPRAYS + WATER TRUCK    29.6       11.4
 PIPELINE CHARGING         .02  .0190  .0000  .0080     49     59     0    24 UNCONTROLLED                     .0         .0
 REDLER CHARGING           .01  .0060  .0000  .0049     13      7     0     6 UNCONTROLLED                     .0         .0
 HOT LARRY CAR CHARGING    .02  .0190  .0000  .0080     10     12     0     5 UNCONTROLLED                     .0         .0
 BY-PRODUCTS PLANT         .00  .3000  .0000  .2000      0  16419     0 10946 UNCONTROLLED                     .0         .0
 COMBUSTION STACK - NEW    .13  .0006  .0000  .0000   2231     10     0     0 UNCONTROLLED                     .0         .0
 QUENCHING - DIRTY WATER   .16  .0010  .0000  .0001   4893     29     1     1 CLEAN WATER, DIV. FLOW BAFFLES 341.1      183.6


  TOTAL UNC.               9.3  2.235   .006   .686 508238 122349   337 37577
  EXISTING CONTROL                                  388402  76172   254 17656                               297.5      197.1
  EXISTING EFFICIENCY                                 23.6   37.7  24.6  53.0
  BASELINE CONTROL                                  508237 122348   337 37577                                  .0         .0
  BASELINE EFFICIENCY                                   .0     .0    .0    .0
  TOTAL CONTROLLED                                   76176  73707   244 17533                              1897.1      786.6
  PERCENT CONTROLLED                                  85.0   39.8  27.6  53.3

              EXISTING                                         NEW
     TOTAL BATTERIES 216    TOTAL OVENS 12221        TOTAL BATTERIES   0    TOTAL OVENS     0

     TOTAL CAPACITY  109494267  TONS COAL            TOTAL CAPACITY          0  TONS COAL

                      76623000  TONS COKE                                    0  TONS COKE

     * NOT IN OPTIMIZATION
```

TABLE 16. MODEL OUTPUT FOR 90 PERCENT OVERALL PARTICULATE REDUCTION

```
                    COKE OVEN OPTIMIZATION

      OBJECTIVE: MINIMUM ANNUALIZED COST RESTRICTION:  90.0%  OVERALL EFFICIENCY  POLLUTANT:TSP         BASE YEAR 1979
      BASELINE: ASSUMING NO SIP OR EXISTING CONTROLS

                                          CONTROLLED EMISSIONS                                                    CONTROLLED COST
                                     (LBS/TON COAL)             (TONS/YEAR)                                       (MILLION DOLLARS)

       SOURCE                 TSP    BSO    BAP    BEN    TSP    BSO    BAP    BEN    CONTROL SCHEME              CAPITAL  ANNUALIZED
 LARRY CAR CHARGING           .01  .0110  .0000  .0050    496    545      0    248 NEW CAR, STEAM, BOOT           303.6     164.7
 COKE PUSHING               * .23  .0408  .0000  .0031  12366   2234      1    167 ENCLOSED HOT CAR               429.2     135.4
 QUENCHING - CLEAN WATER      .17  .0002  .0000  .0000   4104      4      0      0 DIVERTED FLOW BAFFLES           58.0      14.0
 DOORS                        .40  .5000  .0030  .0200  21892  27365    164   1094 UNCONTROLLED                      .0        .0
 TOPSIDE                      .01  .0075  .0000  .0002    328    410      1      8 NEW LIDS & CASTINGS             21.8      63.0
 COMBUSTION STACK - OLD       .03  .0030  .0000  .0000    976    112      1      0 BAGHOUSE, 98%                  323.2     111.6
 COKE HANDLING                .11  .0000  .0000  .0000   5965      0      0      0 ENCLOSURES + BAGHOUSE           40.0      16.5
 COAL PREHEATER               .07  .5250  .0002  .0070    359   2675      0     35 ESP 99%                         12.7       5.8
 COAL PREPARATION             .02  .0000  .0000  .0000    820      0      0      0 ENCLOSURE + BAGHOUSE - 99%      29.1      12.7
 COAL STORAGE YARD            .04  .0000  .0000  .0000   2052      0      0      0 UNLOAD SPRAYS + WATER TRUCK     29.6      11.4
 PIPELINE CHARGING            .02  .0190  .0000  .0080     49     59      0     24 UNCONTROLLED                      .0        .0
 REDLER CHARGING              .01  .0060  .0000  .0049     13      7      0      6 UNCONTROLLED                      .0        .0
 HOT LARRY CAR CHARGING       .02  .0190  .0000  .0080     10     12      0      5 UNCONTROLLED                      .0        .0
 BY-PRODUCTS PLANT            .00  .3000  .0000  .2000      0  16419      0  10946 UNCONTROLLED                      .0        .0
 COMBUSTION STACK - NEW       .03  .0001  .0000  .0000    446      2      0      0 OVEN PATCHING                     .0      20.1
 QUENCHING - DIRTY WATER      .03  .0001  .0000  .0000    978      1      0      0 DRY QUENCHING                  799.5     251.4


  TOTAL UNC.                  9.3  2.235   .006   .686 508238 122349    337  37577
  EXISTING CONTROL                                     388402  76172    254  17656                                297.5     197.1
  EXISTING EFFICIENCY                                    23.6   37.7   24.6   53.0
  BASELINE CONTROL                                     508237 122348    337  37577                                   .0        .0
  BASELINE EFFICIENCY                                      .0     .0     .0     .0
  TOTAL CONTROLLED                                      50862  49851    170  12538                              . 2046.8     806.6
  PERCENT CONTROLLED                                     90.0   59.3   49.6   66.6

            EXISTING                                         NEW
      TOTAL BATTERIES 216    TOTAL OVENS 12221        TOTAL BATTERIES   0    TOTAL OVENS     0

      TOTAL CAPACITY  109494267  TONS COAL            TOTAL CAPACITY          0  TONS COAL

                       76623000  TONS COKE                                    0  TONS COKE

      * NOT IN OPTIMIZATION
```

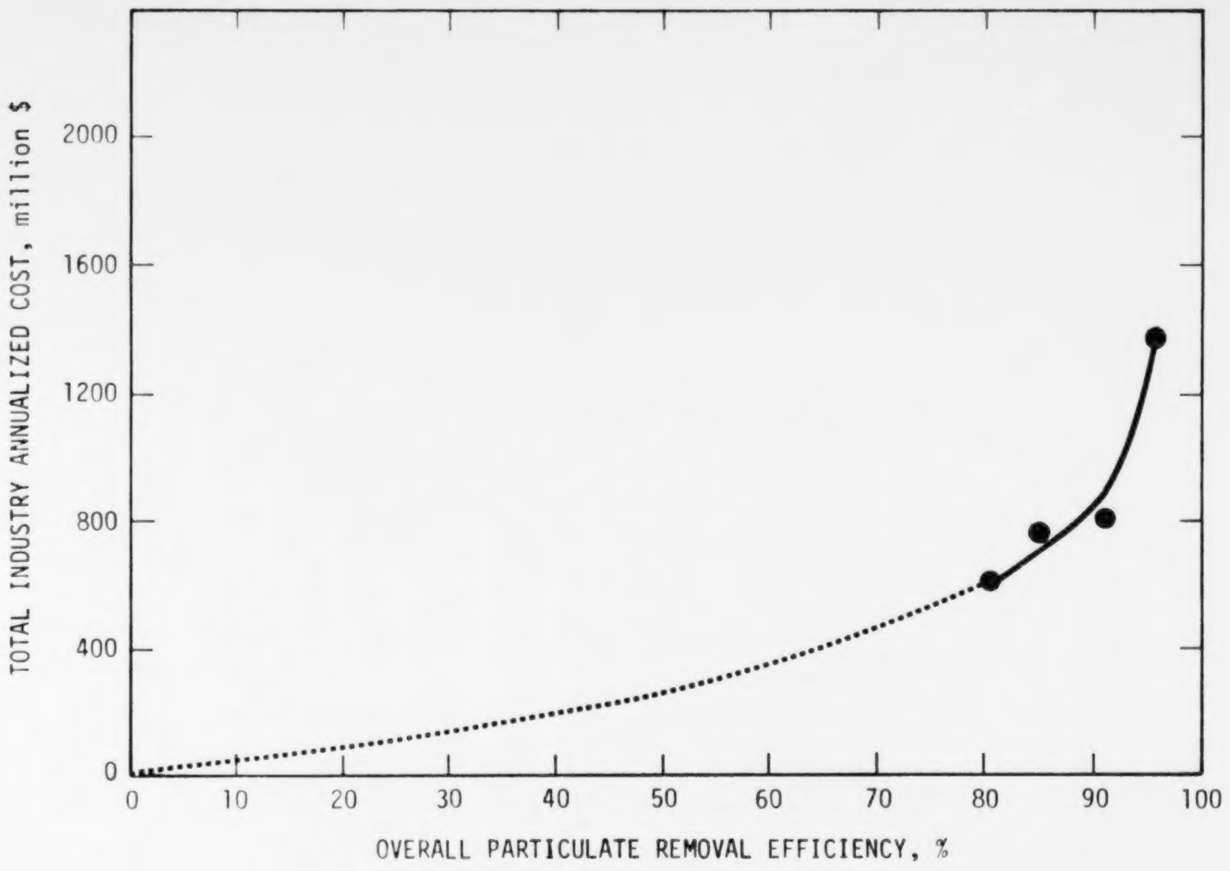


Figure 21. Total annualized cost as a function of overall efficiency.

Clearly these examples represent only a few of the cases that can be evaluated. Furthermore, the results for other pollutants and emission factors, control cost functions, and battery subsets have not been examined. These are among the many possibilities that remain for the users of the model.

APPENDIX A

EXAMPLE COMPUTER PRINTOUTS FOR COST FUNCTIONS PRESENTLY INCLUDED IN MODEL

Complete and detailed printouts for each control option have been provided to the Project Officer as data supplements for the three plant sizes. Table A-1 is a summary of all the cost functions. This appendix also includes summary pages for each control option for the large plant. Each set of pages is arranged in ascending order according to source number and control option number (as indicated at the top of every page). The first page contains general information and the second page describes the control system. The third page summarizes the capital cost (if applicable) and the fourth page summarizes the annualized cost.

TABLE A-1. COST FUNCTION COEFFICIENTS FOR CONTROL OPTIONS[a]
(cost in fourth quarter 1978 dollars)

Source control option	Basis for X value	New Installation				Retrofit Installation			
		Capital cost		Annualized cost coefficient		Capital cost coefficient		Annualized cost coefficient	
		A	B	A	B	A	B	A	B
Wet coal charging	Battery								
Modified larry car		290,539.2	0.0250	227,751.9	0.0762	319,187.0	0.0251	230,194.8	0.0761
New larry car		2,784.7	0.4882	68,022.8	0.1934	3,064.5	0.4882	63,015.2	0.2014
New larry car & second main		326,894.4	0.1935	341,620.2	0.1117	293,877.1	0.2046	320,512.5	0.1178
Coke pushing	Battery								
Controlled coking		0	0	25.7	0.9593	0	0	25.7	0.9593
Shed and ESP, 95%		17,498.8	0.4228	3,177.5	0.4737	22,052.2	0.4141	3,659.2	0.4670
Shed and scrubber, 95%		25,028.5	0.4223	7,752.5	0.4439	30,128.9	0.4166	8,519.4	0.4403
Enclosed hot car		423,778.8	0.1938	70,214.2	0.2354	466,163.3	0.1938	76,212.7	0.2332
Shed and ESP, 99%		14,710.7	0.4422	2,907.6	0.4836	18,452.7	0.4337	3,345.8	0.4771
Shed and scrubber, 99%		23,357.7	0.4310	5,243.8	0.4823	28,061.2	0.4254	5,825.5	0.4776
Quenching, clean water	Plant								
Conventional baffles		1.7	0.8412	0.4	0.8750	2.1	0.8412	0.4	0.8707
Diverted flow baffles		82.6	0.7119	9.5	0.7714	107.5	0.7119	12.7	0.7621
Dry quenching[b]		771.8	0.7065	87.6	0.7683	848.9	0.7065	96.8	0.7651
Doors	Battery								
Cleaning and maintenance		0	0	804,801.2	0	0	0	804,801.2	0
High pressure water cleaning		414,499.8	0	876,701.5	0	414,499.8	0	876,701.5	0
Door hoods, scrubber, 95%		18,558.0	0.3453	954,615.0	0.0624	21,613.0	0.3487	880,426.2	0.0708
Door hoods, scrubber, 98%		21,562.1	0.3441	879,789.9	0.0715	25,298.2	0.3465	812,304.1	0.0800
Door hoods, scrubber, 95% one side		13,431.0	0.3409	106,371.0	0.0431	15,000.0	0.3443	998,158.0	0.0496
Door hoods, scrubber, 98% one side		11,682.0	0.3620	863,212.0	0.0614	13,625.0	0.3638	808,202.0	0.0682
Topside	Battery								
Luting and cleaning		0	0	264,900.1	0	0	0	264,900.1	0
Luting, cleaning, and maintenance		0	0	503,300.4	0	0	0	503,300.4	0
New lids, luting, and cleaning		81,100.0	0	300,799.9	0	105,399.9	0	304,299.8	0
Combustion stack, old	Battery								
Oven patching		0	0	503,300.4	0	0	0	503,300.4	0
Dry ESP, 90%		2,534.3	0.5283	5,373.4	0.3994	2,976.1	0.5306	5,061.8	0.4101
Dry ESP, 98%		2,609.3	0.5484	3,989.6	0.4333	3,085.1	0.5500	3,800.7	0.4440
Fabric filter, 98%		418.3	0.6518	551.5	0.5543	515.9	0.6504	546.8	0.5616

(continued)

TABLE A-1 (continued)

Source control option	Basis for X value	New Installation				Retrofit Installation			
		Capital cost		Annualized cost coefficient		Capital cost coefficient		Annualized cost coefficient	
		A	B	A	B	A	B	A	B
Coke handling	Plant								
Enclosures and fabric filters		196.0	0.5789	111.2	0.5612	207.7	0.5823	112.9	0.5629
Coal preheater	Battery								
Scrubber, 95%		2,083.4	0.4691	131,626.3	0.1515	2,244.9	0.4704	123,839.7	0.1574
Dry ESP, 95%		1,869.5	0.4688	52,969.1	0.1785	2,007.5	0.4702	49,467.6	0.1855
Scrubber, 98%		2,051.3	0.4724	102,188.8	0.1719	2,211.2	0.4737	96,494.4	0.1755
Dry ESP, 99%		1,944.9	0.4799	41,863.8	0.2006	2,095.3	0.4811	38,805.0	0.2084
Coal preparation	Plant								
Enclosures and fabric filter		682.6	0.4686	2,893.9	0.3108	693.2	0.4746	2,710.6	0.3180
Coal storage	Plant								
Water spray truck		159,450.1	0.0341	76,052.9	0.0428	179,919.7	0.0336	79,334.9	0.0422
Water spray truck and unloading sprays		314,191.3	0.0245	101,422.0	0.0443	372,093.4	0.0231	110,347.1	0.0424
Coal pile sprays		42.5	0.7780	13.4	0.8097	53.3	0.7695	14.8	0.8055
Pipeline charging	Battery								
Operating and maintenance program		0	0	539,800.0	0	0	0	593,800.0	0
Redler charging	Battery								
Operating and maintenance program		0	0	358,100.3	0	0	0	358,100.3	0
Hot larry car charging	Battery								
Operating and maintenance program		0	0	264,900.1	0	0	0	264,900.1	0
Byproducts plant	Plant								
Maintenance program		0	0	300,000.0	0	0	0	300,000.0	0
Combustion stack, new oven patching	Battery	0	0	503,300.4	0	0	0	503,300.4	0
Quenching, dirty water	Plant								
Conventional baffles		1.7	0.8412	0.3	0.8944	2.1	0.8412	0.4	0.8888
Conventional baffles and clean water			0.4319	348.3	0.6848	21,656.8	0.4328	436.3	0.6724
Diverted flow baffles and clean water		11,753.1	0.4765	352.8	0.6894	13,599.2	0.4802	440.6	0.6779
Dry quenching[c]				838.3	0.6503			967.5	0.6448

[a] Cost = AX^B; X = tons of coke/year.

[b] Annualized cost does not account for potential steam credit.

[c] Annualized cost does not account for potential steam credit except for steam used in water treatment.

INDEX TO COST SHEETS

Source	Option	Page
Larry car charging	2	A-5
	3	A-9
	4	A-13
Coke pushing	2	A-17
	3	A-20
	4	A-24
	5	A-28
	6	A-32
	7	A-36
Quenching, clean water	2	A-40
	3	A-44
	4	A-48
Doors	2	A-52
	3	A-55
	4	A-59
	5	A-63
	6	A-67
	7	A-71
Topside	2	A-75
	3	A-78
	4	A-81
Combustion stack, old	2	A-85
	3	A-88
	4	A-92
	5	A-96
Coke handling	2	A-100
Coal preheater	2	A-104
	3	A-108
	4	A-112
	5	A-116
Coal preparation	2	A-120
Coal storage	2	A-124
	3	A-128
	4	A-132
Pipeline charging	2	A-136
Redler charging	2	A-139
Hot larry car charging	2	A-142
Byproducts plant	2	A-145
Combustion stack, new	2	A-148
Quenching, dirty water	2	A-151
	3	A-154
	4	A-158
	5	A-162

```
GENERAL INFORMATION:
                                                       UNITS    OPTION
    PPSES:  501.    LARRY CAR CHARGING                  COKE       2

    CAPACITY:                .708 MILLION TONS/YEAR

    PARTICULATE
         LOAD IN:     1.000000 LBS/TON COAL
         ALLOWABLE:    .200000 LBS/TON COAL    EFFICIENCY:  80.0%
                         23.10  LBS/HR

    BSO
         LOAD IN:     1.100000 LBS/TON COAL
         ALLOWABLE:    .220000 LBS/TON COAL    EFFICIENCY:  80.0%
                         25.41  LBS/HR

    BAP
         LOAD IN:      .002000 LBS/TON COAL
         ALLOWABLE:    .000400 LBS/TON COAL    EFFICIENCY:  80.0%
                           .05  LBS/HR

    BENZENE
         LOAD IN:      .500000 LBS/TON COAL
         ALLOWABLE:    .100000 LBS/TON COAL    EFFICIENCY:  80.0%
                         11.55  LBS/HR

    DUST COLLECTED PER DAY:          1.1 TONS(DRY)

    TEMP OUT OF PROCESS:          180. F
    EXHAUST TEMPERATURE:          180. F

    SCFM FLOW:          0.    AT    70. F
    ACFM FLOW:          0.    AT   180. F

    L/G RATIO:                      .0
    PROCESS WATER FLOW:            0. GPM
    COOLING WATER FLOW:            0. GPM
    SUSPENDED SOLIDS OUT:          0. MG/L      %SOLIDS:    .0
```

```
GENERAL INFORMATION:
                                                        UNITS   OPTION
     PPSES:  501.   LARRY CAR CHARGING                  COKE       2


     CONTROL SYSTEM CONFIGURATION:

          LARRY CAR
          LEVELING BAR SMOKE SEAL
          STEAM SUPPLY


     FEET OF ADDITIONAL DUCT:              0.     DIAMETER:  0.
     TOTAL PRESSURE DROP:                  0. INCHES
     0 FANS @    0. HP EACH       SPARE FAN CAPACITY:    0.%
     OPERATING HOURS AT FULL HP:     8760.
     OPERATING HOURS AT REDUCED HP:        0.
     STACK HEIGHT:                         0.    DIAMETER:  0.
     NO. OF OVENS                         60.
     OVEN HEIGHT                           6.0 METERS
     OVEN VOLUME                        1348.  CUBIC FEET
     TONS COKE/PUSH                       24.
     AVG. COKING TIME,HRS.                17.5
     NO. CYCLES/DAY                       82.
     BULK DENSITY                         50.  LBS/CUBIC FT.
     YIELD                                  .70
     TONS COAL/YEAR                  1011967.
```

```
CAPITAL COST:
                                                      UNITS    OPTION
     PPSES:  501.   LARRY CAR CHARGING                COKE       2

     CAPACITY:            .708 MILLION TONS/YEAR

     TOTAL COST      (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.

            CATEGORY                              COST IN DOLLARS

                        *** DIRECT  COST ***
            EQUIPMENT OR MATERIAL                 110500.
            INSTRUMENTATION                            0.
            PIPING                                 15000.
            ELECTRICAL                              7500.
            FOUNDATIONS                                0.
            STRUCTURAL                             45700.
            SITE WORK                                  0.
            INSULATION                             18100.
            PROTECTIVE COATING                       400.
            BUILDINGS                                  0.
            EQUIPMENT/MATERIAL LABOR               37000.
                 DIRECT COST SUBTOTAL                             234200.

                       *** INDIRECT  COST ***
            FIELD OVERHEAD                         30400.
            CONTRACTORS FEE                        17900.
            ENGINEERING                            21600.
            FREIGHT                                 2400.
            OFFSITE WORK                               0.
            TAXES                                   8200.
            SHAKEDOWN                               4600.
            SPARES                                  5600.
            CONTINGENCY                            65200.
                 INDIRECT COST SUBTOTAL                           155900.

                 INTEREST DURING INSTALLATION                      16700.

                 TOTAL COST                                       406800.

                 TOTAL COST WITH RETROFIT                         447500.
```

```
OPERATING COST:
                                                      UNITS    OPTION
    PPSES:  501.   LARRY CAR CHARGING                 COKE       2

    CAPACITY:            .708 MILLION TONS/YEAR

    CATEGORY             QUANTITY          RATE                 ANNUAL COST ($

                              *** UTILITIES ***

    WATER                  0. MGAL/YR    $  .1595/1000 GAL               0.
    ELECTRICITY            0. KWH/YR     $  .0266/KWH                    0.
    STEAM              17001. MLBS/YR    $ 4.0920/MLBS               69600.
    FUEL                   0. GAL/YR     $  .4180/GAL                    0.

                           *** OPERATING LABOR ***

    DIRECT              8760. HRS/YR      $14.34/HR                 125700. (A)
    SUPERVISION         1752. HRS/YR      $17.20/HR                  30100. (B)

                        *** MAINTENANCE & SUPPLIES ***

    DIRECT LABOR        5200. HRS/YR      $14.34/HR                  74600. (C)
    SUPERVISION         1040. HRS/YR      $17.20/HR                  17900. (D)
    MATERIALS                                                        36700. (E)
    SUPPLIES                                                         19400. (F)
    WATER TREATMENT                                                      0.
    SOLID WASTE
      DISPOSAL             0. TON/YR      $ 8.25/TON                     0.

         DIRECT OPERATING COST                                      374000.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                          49700.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                       152200.
         TOTAL OPERATING COST                                       575900.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                 .81
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED        1422.72
         OPERATING COST AS PERCENT OF CAPITAL COST                    128.7
         INSTALLATION TIME IN WEEKS                                     52.
         ESTIMATED LIFE OF SYSTEM IN YEARS                              25.
         KWH PER TON    CAPACITY                                         .0
         CAPITAL RECOVERY (11.02% OF TOTAL CAPITAL)                  49300.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)             9000.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)               9000.
         TOTAL ANNUALIZED COST - RETROFIT                           643200.
                               - NEW                                636900.
```

```
GENERAL INFORMATION:
                                                    UNITS    OPTION
     PPSES:  501.   LARRY CAR CHARGING              COKE       3

     CAPACITY:           .708 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:    1.000000 LBS/TON COAL
          ALLOWABLE:   .010000 LBS/TON COAL   EFFICIENCY:  99.0%
                      1.16     LBS/HR

     BSO
          LOAD IN:    1.100000 LBS/TON COAL
          ALLOWABLE:   .011000 LBS/TON COAL   EFFICIENCY:  99.0%
                      1.27     LBS/HR

     BAP
          LOAD IN:     .002000 LBS/TON COAL
          ALLOWABLE:   .000020 LBS/TON COAL   EFFICIENCY:  99.0%
                       .00     LBS/HR

     BENZENE
          LOAD IN:     .500000 LBS/TON COAL
          ALLOWABLE:   .005000 LBS/TON COAL   EFFICIENCY:  99.0%
                       .58     LBS/HR

     DUST COLLECTED PER DAY:       1.4 TONS(DRY)

     TEMP OUT OF PROCESS:       180. F
     EXHAUST TEMPERATURE:       180. F

     SCFM FLOW:        0.    AT    70. F
     ACFM FLOW:        0.    AT   180. F

     L/G RATIO:                    .0
     PROCESS WATER FLOW:          0. GPM
     COOLING WATER FLOW:          0. GPM
     SUSPENDED SOLIDS OUT:        0. MG/L     %SOLIDS:    .0
```

```
CAPITAL COST:
                                                   UNITS   OPTION
    PPSES:  501.   LARRY CAR CHARGING               COKE       3

    CAPACITY:             .708 MILLION TONS/YEAR

    TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST

         CATEGORY                              COST IN DOLLARS

                   *** DIRECT  COST ***
         EQUIPMENT OR MATERIAL            1222600.
         INSTRUMENTATION                        0.
         PIPING                                 0.
         ELECTRICAL                             0.
         FOUNDATIONS                            0.
         STRUCTURAL                             0.
         SITE WORK                              0.
         INSULATION                         17000.
         PROTECTIVE COATING                     0.
         BUILDINGS                              0.
         EQUIPMENT/MATERIAL LABOR          117700.
              DIRECT COST SUBTOTAL                         1357300.

                  *** INDIRECT  COST ***
         FIELD OVERHEAD                     39100.
         CONTRACTORS FEE                    19100.
         ENGINEERING                        14500.
         FREIGHT                            18000.
         OFFSITE WORK                           0.
         TAXES                              57000.
         SHAKEDOWN                           6100.
         SPARES                             57100.
         CONTINGENCY                       297200.
              INDIRECT COST SUBTOTAL                        508100.

              INTEREST DURING INSTALLATION                  136600.

              TOTAL COST                                   2002000.

              TOTAL COST WITH RETROFIT                     2202200.
```

```
GENERAL INFORMATION:
                                                         UNITS    OPTION
      PPSES:  501.   LARRY CAR CHARGING                  COKE       3


      CONTROL SYSTEM CONFIGURATION:

           LARRY CAR
           LEVELING BAR SMOKE SEAL
           STEAM SUPPLY


      FEET OF ADDITIONAL DUCT:              0.    DIAMETER:  0.
      TOTAL PRESSURE DROP:                  0. INCHES
      0 FANS @     0. HP EACH       SPARE FAN CAPACITY:    0.%
      OPERATING HOURS AT FULL HP:      8760.
      OPERATING HOURS AT REDUCED HP:     0.
      STACK HEIGHT:                         0.    DIAMETER:  0.
      NO. OF OVENS                         60.
      OVEN HEIGHT                          6.0 METERS
      OVEN VOLUME                        1348.  CUBIC FEET
      TONS COKE/PUSH                       24.
      AVG. COKING TIME,HRS.                17.5
      NO. CYCLES/DAY                       82.
      BULK DENSITY                         50.  LBS/CUBIC FT.
      YIELD                                 .70
      TONS COAL/YEAR                  1011967.
```

```
OPERATING COST:
                                                    UNITS    OPTION
    PPSES:  501.   LARRY CAR CHARGING               COKE       3

    CAPACITY:           .708 MILLION TONS/YEAR

    CATEGORY                 QUANTITY         RATE                ANNUAL COST ($)

                                  *** UTILITIES ***

    WATER                      0. MGAL/YR    $  .1595/1000 GAL             0.
    ELECTRICITY                0. KWH/YR     $  .0266/KWH                  0.
    STEAM                  17001. MLBS/YR    $ 4.0920/MLBS             69600.
    FUEL                       0. GAL/YR     $  .4180/GAL                  0.

                               *** OPERATING LABOR ***

    DIRECT                  8760. HRS/YR     $14.34/HR                125700. (A)
    SUPERVISION             1752. HRS/YR     $17.20/HR                 30100. (B)

                            *** MAINTENANCE & SUPPLIES ***

    DIRECT LABOR            6200. HRS/YR     $14.34/HR                 88900. (C)
    SUPERVISION             1240. HRS/YR     $17.20/HR                 21300. (D)
    MATERIALS                                                          43900. (E)
    SUPPLIES                                                           23100. (F)
    WATER TREATMENT                                                        0.
    SOLID WASTE
      DISPOSAL                 0. TON/YR     $ 8.25/TON                    0.

         DIRECT OPERATING COST                                        402600.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                            53200.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                         166500.
         TOTAL OPERATING COST                                         622300.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                   .88
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED          1242.31
         OPERATING COST AS PERCENT OF CAPITAL COST                       28.3
         INSTALLATION TIME IN WEEKS                                       80.
         ESTIMATED LIFE OF SYSTEM IN YEARS                                25.
         KWH PER TON    CAPACITY                                          .0
         CAPITAL RECOVERY (11.02% OF TOTAL CAPITAL)                   242600.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)              44000.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                44000.
         TOTAL ANNUALIZED COST - RETROFIT                             952900.
                               - NEW                                  922900.
```

```
GENERAL INFORMATION:
                                                   UNITS    OPTION
        PPSES:  501.   LARRY CAR CHARGING           COKE       4

        CAPACITY:            .708 MILLION TONS/YEAR

        PARTICULATE
             LOAD IN:    1.000000 LBS/TON COAL
             ALLOWABLE:   .005000 LBS/TON COAL    EFFICIENCY:   99.5%
                              .58  LBS/HR

        BSO
             LOAD IN:    1.100000 LBS/TON COAL
             ALLOWABLE:   .005500 LBS/TON COAL    EFFICIENCY:   99.5%
                              .64  LBS/HR

        BAP
             LOAD IN:     .002000 LBS/TON COAL
             ALLOWABLE:   .000010 LBS/TON COAL    EFFICIENCY:   99.5%
                              .00  LBS/HR

        BENZENE
             LOAD IN:     .500000 LBS/TON COAL
             ALLOWABLE:   .002500 LBS/TON COAL    EFFICIENCY:   99.5%
                              .29  LBS/HR

        DUST COLLECTED PER DAY:        1.4 TONS(DRY)

        TEMP OUT OF PROCESS:          180. F
        EXHAUST TEMPERATURE:          180. F

        SCFM FLOW:          0.    AT   70. F
        ACFM FLOW:          0.    AT  180. F

        L/G RATIO:                       .0
        PROCESS WATER FLOW:             0. GPM
        COOLING WATER FLOW:             0. GPM
        SUSPENDED SOLIDS OUT:           0. MG/L      %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                      UNITS    OPTION
     PPSES:  501.   LARRY CAR CHARGING                COKE       4

     CONTROL SYSTEM CONFIGURATION:

            LARRY CAR
            LEVELING BAR SMOKE SEAL
            STEAM SUPPLY
            SECOND COLLECTING MAIN

     FEET OF ADDITIONAL DUCT:               0.     DIAMETER:  0.
     TOTAL PRESSURE DROP:                   0. INCHES
     0 FANS @    0. HP EACH        SPARE FAN CAPACITY:    0.%
     OPERATING HOURS AT FULL HP:      8760.
     OPERATING HOURS AT REDUCED HP:     0.
     STACK HEIGHT:                          0.     DIAMETER:  0.
     NO. OF OVENS                         60.
     OVEN HEIGHT                            6.0 METERS
     OVEN VOLUME                        1348.  CUBIC FEET
     TONS COKE/PUSH                       24.
     AVG. COKING TIME,HRS.                17.5
     NO. CYCLES/DAY                       82.
     BULK DENSITY                         50.  LBS/CUBIC FT.
     YIELD                                 .70
     TONS COAL/YEAR                  1011967.
```

```
CAPITAL COST:
                                                   UNITS   OPTION
        PPSES:  501.   LARRY CAR CHARGING          COKE       4

        CAPACITY:           .708 MILLION TONS/YEAR

        TOTAL COST      (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4078 COST

              CATEGORY                         COST IN DOLLARS

                         *** DIRECT  COST ***
              EQUIPMENT OR MATERIAL            2410600.
              INSTRUMENTATION                        0.
              PIPING                                 0.
              ELECTRICAL                             0.
              FOUNDATIONS                            0.
              STRUCTURAL                             0.
              SITE WORK                              0.
              INSULATION                         17000.
              PROTECTIVE COATING                     0.
              BUILDINGS                              0.
              EQUIPMENT/MATERIAL LABOR          117700.
                   DIRECT COST SUBTOTAL                     2545300.

                        *** INDIRECT  COST ***
              FIELD OVERHEAD                    158300.
              CONTRACTORS FEE                   138300.
              ENGINEERING                       252900.
              FREIGHT                            77600.
              OFFSITE WORK                       19900.
              TAXES                             116600.
              SHAKEDOWN                         125300.
              SPARES                            116700.
              CONTINGENCY                       690500.
                   INDIRECT COST SUBTOTAL                   1696100.

                   INTEREST DURING INSTALLATION              196000.

                   TOTAL COST                               4437400.

                   TOTAL COST WITH RETROFIT                 4637600.
```

```
OPERATING COST:
                                                       UNITS   OPTION
       PPSES:  501.   LARRY CAR CHARGING               COKE      4

       CAPACITY:            .708 MILLION TONS/YEAR

       CATEGORY             QUANTITY          RATE                  ANNUAL COST (

                                  *** UTILITIES ***

       WATER                    0. MGAL/YR     $  .1595/1000 GAL            0.
       ELECTRICITY              0. KWH/YR      $  .0266/KWH                 0.
       STEAM                17001. MLBS/YR     $ 4.0920/MLBS            69600.
       FUEL                     0. GAL/YR      $  .4180/GAL                 0.

                               *** OPERATING LABOR ***

       DIRECT                8760. HRS/YR      $14.34/HR               125700. (A)
       SUPERVISION           1752. HRS/YR      $17.20/HR                30100. (B)

                           *** MAINTENANCE & SUPPLIES ***

       DIRECT LABOR         11600. HRS/YR      $14.34/HR               166400. (C)
       SUPERVISION           2320. HRS/YR      $17.20/HR                39900. (D)
       MATERIALS                                                        82600. (E)
       SUPPLIES                                                         43300. (F)
       WATER TREATMENT                                                      0.
       SOLID WASTE
         DISPOSAL               0. TON/YR      $ 8.25/TON                   0.

          DIRECT OPERATING COST                                        557600.

          PAYROLL OVERHEAD =20.0% OF A+B+C+D                            72400.
          PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                         244000.
          TOTAL OPERATING COST                                         874000.
          OPERATING COST IN DOLLARS PER TON   PRODUCTION                  1.23
          OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED          1736.01
          OPERATING COST AS PERCENT OF CAPITAL COST                      18.6
          INSTALLATION TIME IN WEEKS                                      80.
          ESTIMATED LIFE OF SYSTEM IN YEARS                               25.
          KWH PER TON    CAPACITY                                          .0
          CAPITAL RECOVERY (11.02% OF TOTAL CAPITAL)                   510900.
          ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)              92800.
          PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                92800.
          TOTAL ANNUALIZED COST - RETROFIT                            1570500.
                                - NEW                                 1540300.
```

```
GENERAL INFORMATION:
                                                          UNITS    OPTION
     PPSES:  502.    COKE PUSHING                         COKE       2

     CAPACITY:               .708 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:    2.000000 LBS/TON COAL
          ALLOWABLE:   .800000 LBS/TON COAL   EFFICIENCY:  60.0%
                         92.42 LBS/HR

     BSO
          LOAD IN:     .080000 LBS/TON COAL
          ALLOWABLE:   .032000 LBS/TON COAL   EFFICIENCY:  60.0%
                          3.70 LBS/HR

     BAP
          LOAD IN:     .000040 LBS/TON COAL
          ALLOWABLE:   .000016 LBS/TON COAL   EFFICIENCY:  60.0%
                           .00 LBS/HR

     BENZENE
          LOAD IN:     .006000 LBS/TON COAL
          ALLOWABLE:   .002400 LBS/TON COAL   EFFICIENCY:  60.0%
                           .28 LBS/HR

     DUST COLLECTED PER DAY:        1.7 TONS(DRY)

     TEMP OUT OF PROCESS:         300. F
     EXHAUST TEMPERATURE:         300. F

     SCFM FLOW:        0.    AT    70. F
     ACFM FLOW:        0.    AT   300. F

     L/G RATIO:                     .0
     PROCESS WATER FLOW:          0. GPM
     COOLING WATER FLOW:          0. GPM
     SUSPENDED SOLIDS OUT:        0. MG/L      %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                         UNITS    OPTION
      PPSES:  502.   COKE PUSHING                        COKE       2


      CONTROL SYSTEM CONFIGURATION:

           CONTROLLED COKING

      FEET OF ADDITIONAL DUCT:              0.    DIAMETER:  0.
      TOTAL PRESSURE DROP:                  0. INCHES
      0 FANS @     0. HP EACH        SPARE FAN CAPACITY:    0.%
      OPERATING HOURS AT FULL HP:      8760.
      OPERATING HOURS AT REDUCED HP:        0.
      STACK HEIGHT:                         0.    DIAMETER:  0.
      NO. OF OVENS                         60.
      OVEN HEIGHT                           6.0 METERS
      OVEN VOLUME                        1346.  CUBIC FEET
      TONS COKE/PUSH                       24.
      AVG. COKING TIME,HRS.                17.5
      NO. CYCLES/DAY                       82.
      BULK DENSITY                         50.  LBS/CUBIC FT.
      YIELD                                  .70
      TONS COAL/YEAR                  1011967.
```

```
OPERATING COST:
                                                   UNITS    OPTION
     PPSES:  502.   COKE PUSHING                   COKE       2

     CAPACITY:            .708 MILLION TONS/YEAR

     CATEGORY             QUANTITY         RATE               ANNUAL COST ($

                              *** UTILITIES ***

     WATER                      0. MGAL/YR    $  .1595/1000 GAL         0.
     ELECTRICITY                0. KWH/YR     $  .0266/KWH              0.
     STEAM                      0. MLBS/YR    $ 4.0920/MLBS             0.
     FUEL                       0. GAL/YR     $  .4180/GAL              0.

                           *** OPERATING LABOR ***

     DIRECT                  8760. HRS/YR     $14.34/HR            125700. (A)
     SUPERVISION             1752. HRS/YR     $17.20/HR             30100. (B)

                        *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR               0. HRS/YR     $14.34/HR                 0. (C)
     SUPERVISION                0. HRS/YR     $17.20/HR                 0. (D)
     MATERIALS                                                          0. (E)
     SUPPLIES                                                     6857100. (F)
     WATER TREATMENT                                                    0.
     SOLID WASTE
       DISPOSAL                 0. TON/YR     $ 8.25/TON                0.

        DIRECT OPERATING COST                                     7012900.

        PAYROLL OVERHEAD =20.0% OF A+B+C+D                          31200.
        PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                      3506500.
        TOTAL OPERATING COST                                     10550600.
        OPERATING COST IN DOLLARS PER TON   PRODUCTION              14.89
        OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED      17376.39
        OPERATING COST AS PERCENT OF CAPITAL COST                      .0
        INSTALLATION TIME IN WEEKS                                     8.
        ESTIMATED LIFE OF SYSTEM IN YEARS                             99.
        KWH PER TON    CAPACITY                                        .0
        CAPITAL RECOVERY (10.00% OF TOTAL CAPITAL)                     0.
        ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)               0.
        PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                 0.
        TOTAL ANNUALIZED COST - RETROFIT                         10550600.
                              - NEW                              10550600.
```

```
GENERAL INFORMATION:
                                                              UNITS    OPTION
    PPSES:  502.   COKE PUSHING                               COKE       3

    CAPACITY:              .708 MILLION TONS/YEAR

    PARTICULATE
         LOAD IN:     2.000000 LBS/TON COAL
         ALLOWABLE:    .290000 LBS/TON COAL    EFFICIENCY:  85.5%
                      35.26    LBS/HR

    BSO
         LOAD IN:      .080000 LBS/TON COAL
         ALLOWABLE:    .044000 LBS/TON COAL    EFFICIENCY:  45.0%
                       5.35    LBS/HR

    BAP
         LOAD IN:      .000040 LBS/TON COAL
         ALLOWABLE:    .000022 LBS/TON COAL    EFFICIENCY:  45.0%
                        .00    LBS/HR

    BENZENE
         LOAD IN:      .006000 LBS/TON COAL
         ALLOWABLE:    .003300 LBS/TON COAL    EFFICIENCY:  45.0%
                        .40    LBS/HR

    DUST COLLECTED PER DAY:       2.4 TONS(DRY)

    TEMP OUT OF PROCESS:         300. F
    EXHAUST TEMPERATURE:         150. F

    SCFM FLOW:  317000.   AT      70. F
    ACFM FLOW:  365000.   AT     150. F

    L/G RATIO:                      .0
    PROCESS WATER FLOW:            0. GPM
    COOLING WATER FLOW:            0. GPM
    SUSPENDED SOLIDS OUT:          0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                        UNITS    OPTION
        PPSES:  502.   COKE PUSHING                      COKE       3

        CONTROL SYSTEM CONFIGURATION:

              ESP
              COKE OVEN SHED
              FAN AND DRIVE
              DUCTWORK
              STACK
              DUST HANDLING HOPPER & CONVEYORS
              DAMPERS
              FAN AND DRIVE ELECTRICAL

        SCA: 188.        TOTAL PLATE AREA:   82000. SQ.FT. @ 20% SPARE CAPACITY
        FEET OF ADDITIONAL DUCT:          300.     DIAMETER: 11.
        TOTAL PRESSURE DROP:               12. INCHES
        3 FANS @  575. HP EACH        SPARE FAN CAPACITY:  50.%
        OPERATING HOURS AT FULL HP:      8322.
        OPERATING HOURS AT REDUCED HP:     0.
        STACK HEIGHT:                     100.     DIAMETER: 12.
        NO. OF OVENS                       60.
        OVEN HEIGHT                        6.0 METERS
        OVEN VOLUME                      1348.  CUBIC FEET
        TONS COKE/PUSH                     24.
        AVG. COKING TIME,HRS.              17.5
        NO. CYCLES/DAY                     82.
        BULK DENSITY                       50.  LBS/CUBIC FT.
        YIELD                               .70
        TONS COAL/YEAR                1011967.
```

```
CAPITAL COST:
                                                     UNITS    OPTION
     PPSES:  502.   COKE PUSHING                     COKE       3

     CAPACITY:              .708 MILLION TONS/YEAR

     TOTAL COST      (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.

          CATEGORY                             COST IN DOLLARS

                   *** DIRECT  COST ***
          EQUIPMENT OR MATERIAL              1740300.
          INSTRUMENTATION                          0.
          PIPING                                   0.
          ELECTRICAL                           71900.
          FOUNDATIONS                          15500.
          STRUCTURAL                           72100.
          SITE WORK                             7900.
          INSULATION                           59900.
          PROTECTIVE COATING                    9600.
          BUILDINGS                             8800.
          EQUIPMENT/MATERIAL LABOR            694500.
               DIRECT COST SUBTOTAL                        2680500.

                   *** INDIRECT  COST ***
          FIELD OVERHEAD                      358100.
          CONTRACTORS FEE                     261400.
          ENGINEERING                         237100.
          FREIGHT                              84400.
          OFFSITE WORK                         48100.
          TAXES                                98000.
          SHAKEDOWN                            95000.
          SPARES                               89200.
          CONTINGENCY                         829900.
               INDIRECT COST SUBTOTAL                      2101200.

               INTEREST DURING INSTALLATION                 429600.

               TOTAL COST                                  5211300.

               TOTAL COST WITH RETROFIT                    5840000.
```

```
OPERATING COST:
                                                        UNITS    OPTION
        PPSES:  502.   COKE PUSHING                     COKE       3

        CAPACITY:            .708 MILLION TONS/YEAR

        CATEGORY             QUANTITY          RATE                 ANNUAL COST ($)

                                  *** UTILITIES ***

        WATER                       0. MGAL/YR    $  .1595/1000 GAL           0.
        ELECTRICITY          8677492. KWH/YR      $  .0266/KWH           231000.
        STEAM                       0. MLBS/YR    $ 4.0920/MLBS               0.
        FUEL                        0. GAL/YR     $  .4180/GAL                0.

                               *** OPERATING LABOR ***

        DIRECT                  8760. HRS/YR     $14.34/HR              125700. (A)
        SUPERVISION             1752. HRS/YR     $17.20/HR               30100. (B)

                            *** MAINTENANCE & SUPPLIES ***

        DIRECT LABOR           11867. HRS/YR     $14.34/HR              170200. (C)
        SUPERVISION             2373. HRS/YR     $17.20/HR               40800. (D)
        MATERIALS                                                        86800. (E)
        SUPPLIES                                                         44700. (F)
        WATER TREATMENT                                                      0.
        SOLID WASTE
          DISPOSAL               865. TON/YR     $ 8.25/TON               7100.

           DIRECT OPERATING COST                                        736400.

           PAYROLL OVERHEAD =20.0% OF A+B+C+D                            73400.
           PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                         249200.
           TOTAL OPERATING COST                                        1059000.
           OPERATING COST IN DOLLARS PER TON   PRODUCTION                  1.49
           OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED          1223.95
           OPERATING COST AS PERCENT OF CAPITAL COST                      18.1
           INSTALLATION TIME IN WEEKS                                     130.
           ESTIMATED LIFE OF SYSTEM IN YEARS                               20.
           KWH PER TON    CAPACITY                                        12.2
           CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                   686000.
           ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)             116800.
           PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)               116800.
           TOTAL ANNUALIZED COST - RETROFIT                            1978600.
                                 - NEW                                 1879500.
```

```
GENERAL INFORMATION:
                                                        UNITS   OPTION
     PPSES:  502.   COKE PUSHING                        COKE      4

     CAPACITY:                .708 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:    2.000000 LBS/TON COAL
          ALLOWABLE:  .290000 LBS/TON COAL    EFFICIENCY:  85.5%
                       35.26  LBS/HR

     BSO
          LOAD IN:     .080000 LBS/TON COAL
          ALLOWABLE:   .040400 LBS/TON COAL   EFFICIENCY:  49.5%
                        4.91  LBS/HR

     BAP
          LOAD IN:     .000040 LBS/TON COAL
          ALLOWABLE:   .000020 LBS/TON COAL   EFFICIENCY:  49.5%
                         .00  LBS/HR

     BENZENE
          LOAD IN:     .006000 LBS/TON COAL
          ALLOWABLE:   .003030 LBS/TON COAL   EFFICIENCY:  49.5%
                         .37  LBS/HR

     DUST COLLECTED PER DAY:        2.4 TONS(DRY)

     TEMP OUT OF PROCESS:         300. F
     EXHAUST TEMPERATURE:         100. F

     SCFM FLOW:  345000.    AT     70. F
     ACFM FLOW:  365000.    AT    100. F

     L/G RATIO:                     7.9
     PROCESS WATER FLOW:         2738. GPM
     COOLING WATER FLOW:            0. GPM
     SUSPENDED SOLIDS OUT:        124. MG/L      %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                     UNITS    OPTION
      PPSES:  502.   COKE PUSHING                    COKE        4

      CONTROL SYSTEM CONFIGURATION:

            VENTURI SCRUBBER
            COKE OVEN SHED
            MIST ELIMINATOR
            FAN AND DRIVE
            DUCTWORK
            STACK
            WASTEWATER RECYCLE SYSTEM
            DAMPERS
            WASTE WATER RETURN SYSTEM
            WATER PUMPING SYSTEM
            FAN AND DRIVE ELECTRICAL

      FEET OF ADDITIONAL DUCT:          300.    DIAMETER: 11.
      TOTAL PRESSURE DROP:               30. INCHES
      3 FANS @ 1436. HP EACH        SPARE FAN CAPACITY:  50.%
      OPERATING HOURS AT FULL HP:      8322.
      OPERATING HOURS AT REDUCED HP:      0.
      STACK HEIGHT:                     100.    DIAMETER: 12.
      NO. OF OVENS                       60.
      OVEN HEIGHT                        6.0 METERS
      OVEN VOLUME                      1346.  CUBIC FEET
      TONS COKE/PUSH                     24.
      AVG. COKING TIME,HRS.              17.5
      NO. CYCLES/DAY                     82.
      BULK DENSITY                       50.  LBS/CUBIC FT.
      YIELD                              .70
      TONS COAL/YEAR                1011967.
```

```
CAPITAL COST:
                                                    UNITS    OPTION
      PPSES:  502.   COKE PUSHING                   COKE       4

      CAPACITY:             .708 MILLION TONS/YEAR

      TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.)

            CATEGORY                              COST IN DOLLARS

                        *** DIRECT  COST ***
            EQUIPMENT OR MATERIAL                2507500.
            INSTRUMENTATION                        51900.
            PIPING                                235000.
            ELECTRICAL                            316500.
            FOUNDATIONS                            89500.
            STRUCTURAL                            123800.
            SITE WORK                              11000.
            INSULATION                             23400.
            PROTECTIVE COATING                     28300.
            BUILDINGS                              38600.
            EQUIPMENT/MATERIAL LABOR              623700.
                DIRECT COST SUBTOTAL                          4049200.

                       *** INDIRECT  COST ***
            FIELD OVERHEAD                        457700.
            CONTRACTORS FEE                       247400.
            ENGINEERING                           396500.
            FREIGHT                                91800.
            OFFSITE WORK                           72800.
            TAXES                                 145800.
            SHAKEDOWN                             136400.
            SPARES                                118400.
            CONTINGENCY                          1131000.
                INDIRECT COST SUBTOTAL                        2797800.

                INTEREST DURING INSTALLATION                   563500.

                TOTAL COST                                    7410500.

                TOTAL COST WITH RETROFIT                      8259100.
```

```
OPERATING COST:
                                                   UNITS    OPTION
        PPSES:  502.   COKE PUSHING                 COKE       4

        CAPACITY:            .708 MILLION TONS/YEAR

        CATEGORY             QUANTITY          RATE                 ANNUAL COST ($)

                                   *** UTILITIES ***

        WATER               273402. MGAL/YR     $  .1595/1000 GAL      43600.
        ELECTRICITY       18980168. KWH/YR      $  .0266/KWH          505300.
        STEAM                    0. MLBS/YR     $ 4.0920/MLBS              0.
        FUEL                     0. GAL/YR      $  .4180/GAL               0.

                                *** OPERATING LABOR ***

        DIRECT                8760. HRS/YR     $14.34/HR              125700. (A)
        SUPERVISION           1752. HRS/YR     $17.20/HR               30100. (B)

                             *** MAINTENANCE & SUPPLIES ***

        DIRECT LABOR         17163. HRS/YR     $14.34/HR              246200. (C)
        SUPERVISION           3433. HRS/YR     $17.20/HR               59100. (D)
        MATERIALS                                                     191100. (E)
        SUPPLIES                                                      110200. (F)
        WATER TREATMENT                                                    0.
        SOLID WASTE
          DISPOSAL            1730. TON/YR     $ 8.25/TON              14300.

           DIRECT OPERATING COST                                     1325600.

           PAYROLL OVERHEAD =20.0% OF A+B+C+D                          92200.
           PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                       381200.
           TOTAL OPERATING COST                                      1799000.
           OPERATING COST IN DOLLARS PER TON   PRODUCTION                2.54
           OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED        2079.21
           OPERATING COST AS PERCENT OF CAPITAL COST                    21.8
           INSTALLATION TIME IN WEEKS                                   130.
           ESTIMATED LIFE OF SYSTEM IN YEARS                             15.
           KWH PER TON    CAPACITY                                      26.8
           CAPITAL RECOVERY (13.15% OF TOTAL CAPITAL)                1085900.
           ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)           165200.
           PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)             165200.
           TOTAL ANNUALIZED COST - RETROFIT                          3215300.
                                 - NEW                               3069700.
```

```
GENERAL INFORMATION:
                                                       UNITS    OPTION
     PPSES:  502.   COKE PUSHING                       COKE        5

     CAPACITY:              .708 MILLION TONS/YEAR

     PARTICULATE
           LOAD IN:    2.000000 LBS/TON COAL
           ALLOWABLE:  .236000 LBS/TON COAL   EFFICIENCY:  88.2%
                         88.45  LBS/HR

     BSO
           LOAD IN:     .080000 LBS/TON COAL
           ALLOWABLE:  .036800 LBS/TON COAL   EFFICIENCY:  54.0%
                         13.79  LBS/HR

     BAP
           LOAD IN:     .000040 LBS/TON COAL
           ALLOWABLE:  .000026 LBS/TON COAL   EFFICIENCY:  36.0%
                           .01  LBS/HR

     BENZENE
           LOAD IN:     .006000 LBS/TON COAL
           ALLOWABLE:  .002760 LBS/TON COAL   EFFICIENCY:  54.0%
                          1.03  LBS/HR

     DUST COLLECTED PER DAY:       2.4 TONS(DRY)

     TEMP OUT OF PROCESS:        300. F
     EXHAUST TEMPERATURE:        100. F

     SCFM FLOW:   71000.    AT    70. F
     ACFM FLOW:   75000.    AT   100. F

     L/G RATIO:                     .0
     PROCESS WATER FLOW:            0. GPM
     COOLING WATER FLOW:            0. GPM
     SUSPENDED SOLIDS OUT:          0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                      UNITS    OPTION
    PPSES:  502.   COKE PUSHING                       COKE       5

    CONTROL SYSTEM CONFIGURATION:

         ENCLOSED HOT CAR

    FEET OF ADDITIONAL DUCT:            0.    DIAMETER:  5.
    TOTAL PRESSURE DROP:                0. INCHES
    0 FANS @     0. HP EACH      SPARE FAN CAPACITY:   0.%
    OPERATING HOURS AT FULL HP:     2700.
    OPERATING HOURS AT REDUCED HP: 5900.
    STACK HEIGHT:                       0.    DIAMETER:  0.
    NO. OF OVENS                       60.
    OVEN HEIGHT                         6.0 METERS
    OVEN VOLUME                      1348.  CUBIC FEET
    TONS COKE/PUSH                     24.
    AVG. COKING TIME,HRS.              17.5
    NO. CYCLES/DAY                     82.
    BULK DENSITY                       50.  LBS/CUBIC FT.
    YIELD                               .70
    TONS COAL/YEAR                1011967.
```

```
CAPITAL COST:
                                                    UNITS   OPTION
    PPSES:  502.   COKE PUSHING                     COKE       5

    CAPACITY:            .708 MILLION TONS/YEAR

    TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.)

         CATEGORY                                COST IN DOLLARS

                       *** DIRECT  COST ***
         EQUIPMENT OR MATERIAL                3841700.
         INSTRUMENTATION                            0.
         PIPING                                     0.
         ELECTRICAL                                 0.
         FOUNDATIONS                                0.
         STRUCTURAL                                 0.
         SITE WORK                                  0.
         INSULATION                                 0.
         PROTECTIVE COATING                         0.
         BUILDINGS                                  0.
         EQUIPMENT/MATERIAL LABOR               23100.
              DIRECT COST SUBTOTAL                          3864800.

                       *** INDIRECT  COST ***
         FIELD OVERHEAD                         11500.
         CONTRACTORS FEE                         3800.
         ENGINEERING                            55000.
         FREIGHT                                 7700.
         OFFSITE WORK                               0.
         TAXES                                 192400.
         SHAKEDOWN                             192400.
         SPARES                                 38500.
         CONTINGENCY                           877500.
              INDIRECT COST SUBTOTAL                        1378800.

              INTEREST DURING INSTALLATION                   524400.

              TOTAL COST                                    5768000.

              TOTAL COST WITH RETROFIT                      6344800.
```

```
OPERATING COST:
                                                        UNITS   OPTION
   PPSES:  502.   COKE PUSHING                           COKE      5

   CAPACITY:                .708 MILLION TONS/YEAR

   CATEGORY                 QUANTITY           RATE                    ANNUAL COST ($)

                                    *** UTILITIES ***

   WATER                    6375. MGAL/YR     $  .1595/1000 GAL          1000.
   ELECTRICITY              4173. KWH/YR      $  .0266/KWH                100.
   STEAM                       0. MLBS/YR     $ 4.0920/MLBS                 0.
   FUEL                   672958. GAL/YR      $  .4180/GAL             281300.

                                 *** OPERATING LABOR ***

   DIRECT                      0. HRS/YR      $14.34/HR                     0. (A)
   SUPERVISION                 0. HRS/YR      $17.20/HR                     0. (B)

                              *** MAINTENANCE & SUPPLIES ***

   DIRECT LABOR             8000. HRS/YR      $14.34/HR                114800. (C)
   SUPERVISION              1600. HRS/YR      $17.20/HR                 27500. (D)
   MATERIALS                                                           114800. (E)
   SUPPLIES                                                             38600. (F)
   WATER TREATMENT                                                          0.
   SOLID WASTE
     DISPOSAL               1785. TON/YR      $ 8.25/TON                14700.

        DIRECT OPERATING COST                                          592800.

        PAYROLL OVERHEAD =20.0% OF A+B+C+D                              28500.
        PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                           147900.
        TOTAL OPERATING COST                                           769200.
        OPERATING COST IN DOLLARS PER TON   PRODUCTION                   1.09
        OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED            861.80
        OPERATING COST AS PERCENT OF CAPITAL COST                        12.1
        INSTALLATION TIME IN WEEKS                                       104.
        ESTIMATED LIFE OF SYSTEM IN YEARS                                 20.
        KWH PER TON   CAPACITY                                           41.8
        CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                     745300.
        ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)               126900.
        PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                 126900.
        TOTAL ANNUALIZED COST - RETROFIT                              1768300.
                              - NEW                                   1677500.
```

```
GENERAL INFORMATION:
                                                        UNITS    OPTION
     PPSES:  502.   COKE PUSHING                        COKE       6

     CAPACITY:              .708 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:    2.000000 LBS/TON COAL
          ALLOWABLE:   .218000 LBS/TON COAL    EFFICIENCY:  89.1%
                         26.51 LBS/HR

     BSO
          LOAD IN:     .080000 LBS/TON COAL
          ALLOWABLE:   .044000 LBS/TON COAL    EFFICIENCY:  45.0%
                          5.35 LBS/HR

     BAP
          LOAD IN:     .000040 LBS/TON COAL
          ALLOWABLE:   .000022 LBS/TON COAL    EFFICIENCY:  45.0%
                           .00 LBS/HR

     BENZENE
          LOAD IN:     .006000 LBS/TON COAL
          ALLOWABLE:   .003300 LBS/TON COAL    EFFICIENCY:  45.0%
                           .40 LBS/HR

     DUST COLLECTED PER DAY:         2.5 TONS(DRY)

     TEMP OUT OF PROCESS:          300. F
     EXHAUST TEMPERATURE:          150. F

     SCFM FLOW:  317000.    AT      70. F
     ACFM FLOW:  365000.    AT     150. F

     L/G RATIO:                      .0
     PROCESS WATER FLOW:            0. GPM
     COOLING WATER FLOW:            0. GPM
     SUSPENDED SOLIDS OUT:          0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                                 UNITS    OPTION
    PPSES:  502.   COKE PUSHING                                  COKE       6


    CONTROL SYSTEM CONFIGURATION:

          ESP
          COKE OVEN SHED
          FAN AND DRIVE
          DUCTWORK
          STACK
          DUST HANDLING HOPPER & CONVEYORS
          DAMPERS
          FAN AND DRIVE ELECTRICAL

    SCA: 240.         TOTAL PLATE AREA:  105000. SQ.FT. @ 20% SPARE CAPACITY
    FEET OF ADDITIONAL DUCT:           300.    DIAMETER: 11.
    TOTAL PRESSURE DROP:                12. INCHES
    3 FANS @  575. HP EACH       SPARE FAN CAPACITY:  50.%
    OPERATING HOURS AT FULL HP:     8322.
    OPERATING HOURS AT REDUCED HP:     0.
    STACK HEIGHT:                      100.    DIAMETER: 12.
    NO. OF OVENS                        60.
    OVEN HEIGHT                         6.0 METERS
    OVEN VOLUME                       1348.  CUBIC FEET
    TONS COKE/PUSH                      24.
    AVG. COKING TIME,HRS.               17.5
    NO. CYCLES/DAY                      82.
    BULK DENSITY                        50.  LBS/CUBIC FT.
    YIELD                                .70
    TONS COAL/YEAR                 1011967.
```

```
CAPITAL COST:
                                                        UNITS    OPTION
     PPSES:  502.   COKE PUSHING                        COKE        6

     CAPACITY:          .708 MILLION TONS/YEAR

     TOTAL COST      (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.

            CATEGORY                                 COST IN DOLLARS

                         *** DIRECT  COST ***
            EQUIPMENT OR MATERIAL               1876100.
            INSTRUMENTATION                           0.
            PIPING                                    0.
            ELECTRICAL                            81100.
            FOUNDATIONS                           16200.
            STRUCTURAL                            81200.
            SITE WORK                              9100.
            INSULATION                            68900.
            PROTECTIVE COATING                    10500.
            BUILDINGS                             10100.
            EQUIPMENT/MATERIAL LABOR             754000.
                 DIRECT COST SUBTOTAL                         2907200.

                        *** INDIRECT  COST ***
            FIELD OVERHEAD                       395300.
            CONTRACTORS FEE                      287400.
            ENGINEERING                          259300.
            FREIGHT                               91500.
            OFFSITE WORK                          54800.
            TAXES                                105400.
            SHAKEDOWN                            106200.
            SPARES                               100400.
            CONTINGENCY                          900700.
                 INDIRECT COST SUBTOTAL                       2301000.

                 INTEREST DURING INSTALLATION                  472100.

                 TOTAL COST                                   5680300.

                 TOTAL COST WITH RETROFIT                     6355900.
```

```
OPERATING COST:
                                                  UNITS    OPTION
     PPSES:  502.   COKE PUSHING                  COKE        6

     CAPACITY:          .708 MILLION TONS/YEAR

     CATEGORY            QUANTITY          RATE              ANNUAL COST ($)

                              *** UTILITIES ***

     WATER                     0. MGAL/YR     $  .1595/1000 GAL          0.
     ELECTRICITY         9151622. KWH/YR      $  .0266/KWH          243600.
     STEAM                     0. MLBS/YR     $ 4.0920/MLBS              0.
     FUEL                      0. GAL/YR      $  .4180/GAL               0.

                           *** OPERATING LABOR ***

     DIRECT                 8760. HRS/YR      $14.34/HR             125700. (A)
     SUPERVISION            1752. HRS/YR      $17.20/HR              30100. (B)

                         *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR          11867. HRS/YR      $14.34/HR             170200. (C)
     SUPERVISION            2373. HRS/YR      $17.20/HR              40800. (D)
     MATERIALS                                                       86800. (E)
     SUPPLIES                                                        44700. (F)
     WATER TREATMENT                                                     0.
     SOLID WASTE
       DISPOSAL              902. TON/YR      $ 8.25/TON              7400.

         DIRECT OPERATING COST                                      749300.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                          73400.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                       249200.
         TOTAL OPERATING COST                                      1071900.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                1.51
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED        1188.80
         OPERATING COST AS PERCENT OF CAPITAL COST                     16.9
         INSTALLATION TIME IN WEEKS                                    130.
         ESTIMATED LIFE OF SYSTEM IN YEARS                              20.
         KWH PER TON    CAPACITY                                       12.9
         CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                 746600.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)           127100.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)             127100.
         TOTAL ANNUALIZED COST - RETROFIT                          2072700.
                               - NEW                               1966300.
```

```
GENERAL INFORMATION:
                                                       UNITS   OPTION
     PPSES:  502.   COKE PUSHING                       COKE      7

     CAPACITY:             .708 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:     2.000000 LBS/TON COAL
          ALLOWABLE:   .218000 LBS/TON COAL    EFFICIENCY:  89.1%
                         26.51  LBS/HR

     BSO
          LOAD IN:      .080000 LBS/TON COAL
          ALLOWABLE:    .036800 LBS/TON COAL   EFFICIENCY:  54.0%
                          4.47  LBS/HR

     BAP
          LOAD IN:      .000040 LBS/TON COAL
          ALLOWABLE:    .000018 LBS/TON COAL   EFFICIENCY:  54.0%
                           .00  LBS/HR

     BENZENE
          LOAD IN:      .006000 LBS/TON COAL
          ALLOWABLE:    .002760 LBS/TON COAL   EFFICIENCY:  54.0%
                           .34  LBS/HR

     DUST COLLECTED PER DAY:        2.5 TONS(DRY)

     TEMP OUT OF PROCESS:        300. F
     EXHAUST TEMPERATURE:        100. F

     SCFM FLOW:  345000.    AT    70. F
     ACFM FLOW:  365000.    AT   100. F

     L/G RATIO:                   7.9
     PROCESS WATER FLOW:        2738. GPM
     COOLING WATER FLOW:           0. GPM
     SUSPENDED SOLIDS OUT:       124. MG/L      %SOLIDS:    .0
```

```
GENERAL INFORMATION:
                                                     UNITS    OPTION
     PPSES:  502.   COKE PUSHING                      COKE       7


     CONTROL SYSTEM CONFIGURATION:

          VENTURI SCRUBBER
          COKE OVEN SHED
          MIST ELIMINATOR
          FAN AND DRIVE
          DUCTWORK
          STACK
          WASTEWATER RECYCLE SYSTEM
          DAMPERS
          WASTE WATER RETURN SYSTEM
          WATER PUMPING SYSTEM
          FAN AND DRIVE ELECTRICAL


     FEET OF ADDITIONAL DUCT:          300.    DIAMETER: 11.
     TOTAL PRESSURE DROP:               50. INCHES
     3 FANS @ 2394. HP EACH        SPARE FAN CAPACITY:  50.%
     OPERATING HOURS AT FULL HP:      8322.
     OPERATING HOURS AT REDUCED HP:      0.
     STACK HEIGHT:                     100.    DIAMETER: 12.
     NO. OF OVENS                       60.
     OVEN HEIGHT                         6.0 METERS
     OVEN VOLUME                      1348.  CUBIC FEET
     TONS COKE/PUSH                     24.
     AVG. COKING TIME,HRS.              17.5
     NO. CYCLES/DAY                     82.
     BULK DENSITY                       50.  LBS/CUBIC FT.
     YIELD                               .70
     TONS COAL/YEAR                1011967.
```

```
CAPITAL COST:
                                                      UNITS   OPTION
     PPSES:  502.   COKE PUSHING                      COKE       7

     CAPACITY:            .708 MILLION TONS/YEAR

     TOTAL COST      (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.

           CATEGORY                              COST IN DOLLARS

                      *** DIRECT  COST ***
           EQUIPMENT OR MATERIAL               2727900.
           INSTRUMENTATION                       51900.
           PIPING                               235000.
           ELECTRICAL                           316500.
           FOUNDATIONS                           95800.
           STRUCTURAL                           126200.
           SITE WORK                             11000.
           INSULATION                            23400.
           PROTECTIVE COATING                    28200.
           BUILDINGS                             38600.
           EQUIPMENT/MATERIAL LABOR             628400.
                DIRECT COST SUBTOTAL                        4282900.

                     *** INDIRECT  COST ***
           FIELD OVERHEAD                       462200.
           CONTRACTORS FEE                      250700.
           ENGINEERING                          396500.
           FREIGHT                               92400.
           OFFSITE WORK                          73300.
           TAXES                                157500.
           SHAKEDOWN                            148900.
           SPARES                               119300.
           CONTINGENCY                         1185700.
                INDIRECT COST SUBTOTAL                      2886500.

                INTEREST DURING INSTALLATION                 604600.

                TOTAL COST                                  7774000.

                TOTAL COST WITH RETROFIT                    8658900.
```

```
OPERATING COST:
                                                       UNITS   OPTION
     PPSES:  502.   COKE PUSHING                       COKE      7

     CAPACITY:           .708 MILLION TONS/YEAR

     CATEGORY             QUANTITY            RATE                ANNUAL COST ($)

                                  *** UTILITIES ***

     WATER               273402. MGAL/YR    $  .1595/1000 GAL          43600.
     ELECTRICITY       31514320. KWH/YR     $  .0266/KWH              838900.
     STEAM                     0. MLBS/YR   $ 4.0920/MLBS                  0.
     FUEL                      0. GAL/YR    $  .4180/GAL                   0.

                              *** OPERATING LABOR ***

     DIRECT                 8760. HRS/YR    $14.34/HR                 125700. (A)
     SUPERVISION            1752. HRS/YR    $17.20/HR                  30100. (B)

                          *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR          17763. HRS/YR    $14.34/HR                 254800. (C)
     SUPERVISION            3553. HRS/YR    $17.20/HR                  61100. (D)
     MATERIALS                                                        197600. (E)
     SUPPLIES                                                         112800. (F)
     WATER TREATMENT                                                       0.
     SOLID WASTE
       DISPOSAL             1803. TON/YR    $ 8.25/TON                 14900.

         DIRECT OPERATING COST                                       1679500.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                            94300.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                         391100.
         TOTAL OPERATING COST                                        2164900.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                  3.06
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED          2401.01
         OPERATING COST AS PERCENT OF CAPITAL COST                       25.0
         INSTALLATION TIME IN WEEKS                                      130.
         ESTIMATED LIFE OF SYSTEM IN YEARS                                15.
         KWH PER TON    CAPACITY                                         44.5
         CAPITAL RECOVERY (13.15% OF TOTAL CAPITAL)                  1138400.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)             173200.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)               173200.
         TOTAL ANNUALIZED COST - RETROFIT                            3649700.
                               - NEW                                 3498000.
```

```
GENERAL INFORMATION:
                                                     UNITS   OPTION
     PPSES:  503.   QUENCHING - CLEAN WATER          COKE      2

     CAPACITY:            2.834 MILLION TONS/YEAR

     PARTICULATE
           LOAD IN:    1.700000 LBS/TON COAL
           ALLOWABLE:   .510000 LBS/TON COAL    EFFICIENCY:  70.0%
                        235.66  LBS/HR

     BSO
           LOAD IN:     .001700 LBS/TON COAL
           ALLOWABLE:   .000510 LBS/TON COAL    EFFICIENCY:  70.0%
                          .24   LBS/HR

     BAP
           LOAD IN:     .000140 LBS/TON COAL
           ALLOWABLE:   .000042 LBS/TON COAL    EFFICIENCY:  70.0%
                          .02   LBS/HR

     BENZENE
           LOAD IN:     .000030 LBS/TON COAL
           ALLOWABLE:   .000030 LBS/TON COAL    EFFICIENCY:    .0%
                          .01   LBS/HR

     DUST COLLECTED PER DAY:       6.6 TONS(DRY)

     TEMP OUT OF PROCESS:         200. F
     EXHAUST TEMPERATURE:         200. F

     SCFM FLOW:  566000.   AT      70. F
     ACFM FLOW:  705000.   AT     200. F

     L/G RATIO:                      .0
     PROCESS WATER FLOW:           0. GPM
     COOLING WATER FLOW:           0. GPM
     SUSPENDED SOLIDS OUT:         0. MG/L     %SOLIDS:    .0
```

```
GENERAL INFORMATION:
                                                      UNITS    OPTION
     PPSES:  503.   QUENCHING - CLEAN WATER           COKE       2

     CONTROL SYSTEM CONFIGURATION:

          QUENCH TOWER BAFFLES

     FEET OF ADDITIONAL DUCT:              0.    DIAMETER: 15.
     TOTAL PRESSURE DROP:                  0. INCHES
     0 FANS @     0. HP EACH       SPARE FAN CAPACITY:   0.%
     OPERATING HOURS AT FULL HP:       8760.
     OPERATING HOURS AT REDUCED HP:        0.
     STACK HEIGHT:                         0.    DIAMETER:  0.
     NO. OF OVENS                         60.
     OVEN HEIGHT                           6.0 METERS
     OVEN VOLUME                        1348.  CUBIC FEET
     TONS COKE/PUSH                       24.
     AVG. COKING TIME,HRS.                17.5
     NO. CYCLES/DAY                       82.
     BULK DENSITY                         50.  LBS/CUBIC FT.
     YIELD                                 .70
     TONS COAL/YEAR                  4047868.
```

```
CAPITAL COST:
                                                 UNITS    OPTION
    PPSES:  503.   QUENCHING - CLEAN WATER       COKE       2

    CAPACITY:          2.834 MILLION TONS/YEAR

    TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.)

          CATEGORY                             COST IN DOLLARS

                    *** DIRECT  COST ***
          EQUIPMENT OR MATERIAL                 114100.
          INSTRUMENTATION                            0.
          PIPING                                 30800.
          ELECTRICAL                              6200.
          FOUNDATIONS                              900.
          STRUCTURAL                                 0.
          SITE WORK                                600.
          INSULATION                                 0.
          PROTECTIVE COATING                       900.
          BUILDINGS                                  0.
          EQUIPMENT/MATERIAL LABOR               80300.
                DIRECT COST SUBTOTAL                       233800.

                    *** INDIRECT  COST ***
          FIELD OVERHEAD                         45400.
          CONTRACTORS FEE                        27900.
          ENGINEERING                            35100.
          FREIGHT                                 4400.
          OFFSITE WORK                               0.
          TAXES                                   5700.
          SHAKEDOWN                               1300.
          SPARES                                  3500.
          CONTINGENCY                            71400.
                INDIRECT COST SUBTOTAL                     194700.

                INTEREST DURING INSTALLATION                10700.

                TOTAL COST                                 439200.

                TOTAL COST WITH RETROFIT                   571000.
```

```
OPERATING COST:
                                                     UNITS    OPTION
   PPSES:  503.   QUENCHING - CLEAN WATER            COKE        2

   CAPACITY:            2.834 MILLION TONS/YEAR

   CATEGORY             QUANTITY           RATE                   ANNUAL COST ($)

                                 *** UTILITIES ***

   WATER                    0. MGAL/YR     $  .1595/1000 GAL                0.
   ELECTRICITY              0. KWH/YR      $  .0266/KWH                     0.
   STEAM                    0. MLBS/YR     $ 4.0920/MLBS                    0.
   FUEL                     0. GAL/YR      $  .4180/GAL                     0.

                              *** OPERATING LABOR ***

   DIRECT                   0. HRS/YR      $14.34/HR                        0. (A)
   SUPERVISION              0. HRS/YR      $17.20/HR                        0. (B)

                           *** MAINTENANCE & SUPPLIES ***

   DIRECT LABOR          1200. HRS/YR      $14.34/HR                    17200. (C)
   SUPERVISION            240. HRS/YR      $17.20/HR                     4100. (D)
   MATERIALS                                                             8600. (E)
   SUPPLIES                                                              4500. (F)
   WATER TREATMENT                                                          0.
   SOLID WASTE
     DISPOSAL            4817. TON/YR      $ 8.25/TON                   39700.

      DIRECT OPERATING COST                                             74100.

      PAYROLL OVERHEAD =20.0% OF A+B+C+D                                 4300.
      PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                              17200.
      TOTAL OPERATING COST                                              95600.
      OPERATING COST IN DOLLARS PER TON   PRODUCTION                       .03
      OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED                39.69
      OPERATING COST AS PERCENT OF CAPITAL COST                          16.7
      INSTALLATION TIME IN WEEKS                                         26.
      ESTIMATED LIFE OF SYSTEM IN YEARS                                  20.
      KWH PER TON    CAPACITY                                              .0
      CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                        67100.
      ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                  11400.
      PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                    11400.
      TOTAL ANNUALIZED COST - RETROFIT                                 185500.
                            - NEW                                      164800.
```

Reproduced from best available copy.

```
GENERAL INFORMATION:
                                                          UNITS    OPTION
        PPSES:  503.   QUENCHING - CLEAN WATER             COKE       3

        CAPACITY:           2.834 MILLION TONS/YEAR

        PARTICULATE
              LOAD IN:    1.700000 LBS/TON COAL
              ALLOWABLE:   .170000 LBS/TON COAL    EFFICIENCY:  90.0%
                          78.55    LBS/HR

        BSO
              LOAD IN:     .001700 LBS/TON COAL
              ALLOWABLE:   .000170 LBS/TON COAL    EFFICIENCY:  90.0%
                           .08     LBS/HR

        BAP
              LOAD IN:     .000140 LBS/TON COAL
              ALLOWABLE:   .000014 LBS/TON COAL    EFFICIENCY:  90.0%
                           .01     LBS/HR

        BENZENE
              LOAD IN:     .000030 LBS/TON COAL
              ALLOWABLE:   .000030 LBS/TON COAL    EFFICIENCY:     .0%
                           .01     LBS/HR

        DUST COLLECTED PER DAY:       8.5 TONS(DRY)

        TEMP OUT OF PROCESS:        200. F
        EXHAUST TEMPERATURE:        150. F

        SCFM FLOW:  566000.   AT     70. F
        ACFM FLOW:  651000.   AT    150. F

        L/G RATIO:                     .0
        PROCESS WATER FLOW:        1213. GPM
        COOLING WATER FLOW:           0. GPM
        SUSPENDED SOLIDS OUT:       907. MG/L      %SOLIDS:     .1
```

```
GENERAL INFORMATION:
                                                   UNITS    OPTION
   PPSES:  503.   QUENCHING - CLEAN WATER          COKE       3


   CONTROL SYSTEM CONFIGURATION:

        QUENCH TOWER BAFFLES

   FEET OF ADDITIONAL DUCT:           0.    DIAMETER: 14.
   TOTAL PRESSURE DROP:               0. INCHES
   0 FANS @    0. HP EACH       SPARE FAN CAPACITY:   0.%
   OPERATING HOURS AT FULL HP:     8760.
   OPERATING HOURS AT REDUCED HP:     0.
   STACK HEIGHT:                      0.    DIAMETER:  0.
   NO. OF OVENS                      60.
   OVEN HEIGHT                        6.0 METERS
   OVEN VOLUME                     1348.  CUBIC FEET
   TONS COKE/PUSH                    24.
   AVG. COKING TIME,HRS.             17.5
   NO. CYCLES/DAY                    82.
   BULK DENSITY                      50.  LBS/CUBIC FT.
   YIELD                               .70
   TONS COAL/YEAR               4047868.
```

```
CAPITAL COST:
                                                     UNITS   OPTION
    PPSES:  503.   QUENCHING - CLEAN WATER           COKE       3

    CAPACITY:         2.834 MILLION TONS/YEAR

    TOTAL COST    (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST

         CATEGORY                                 COST IN DOLLARS

                    *** DIRECT  COST ***
         EQUIPMENT OR MATERIAL                    928400.
         INSTRUMENTATION                           30800.
         PIPING                                    13200.
         ELECTRICAL                                    0.
         FOUNDATIONS                                   0.
         STRUCTURAL                                    0.
         SITE WORK                                  8800.
         INSULATION                                 7900.
         PROTECTIVE COATING                         3500.
         BUILDINGS                                     0.
         EQUIPMENT/MATERIAL LABOR                 654700.
              DIRECT COST SUBTOTAL                          1647300.

                    *** INDIRECT  COST ***
         FIELD OVERHEAD                            70400.
         CONTRACTORS FEE                          338800.
         ENGINEERING                              244200.
         FREIGHT                                       0.
         OFFSITE WORK                              44000.
         TAXES                                     48400.
         SHAKEDOWN                                 26400.
         SPARES                                    44000.
         CONTINGENCY                              638000.
              INDIRECT COST SUBTOTAL                        1454200.

              INTEREST DURING INSTALLATION                   155100.

              TOTAL COST                                    3256600.

              TOTAL COST WITH RETROFIT                      4233600.
```

```
OPERATING COST:
                                                    UNITS    OPTION
     PPSES:  503.   QUENCHING - CLEAN WATER         COKE       3

     CAPACITY:            2.834 MILLION TONS/YEAR

     CATEGORY               QUANTITY         RATE                  ANNUAL COST ($

                                  *** UTILITIES ***

     WATER                        0. MGAL/YR    $  .1595/1000 GAL           0.
     ELECTRICITY                  0. KWH/YR     $  .0266/KWH                0.
     STEAM                        0. MLBS/YR    $ 4.0920/MLBS               0.
     FUEL                         0. GAL/YR     $  .4180/GAL                0.


                               *** OPERATING LABOR ***

     DIRECT                       0. HRS/YR     $14.34/HR                   0. (A)
     SUPERVISION                  0. HRS/YR     $17.20/HR                   0. (B)


                           *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR            4000. HRS/YR     $14.34/HR               57400. (C)
     SUPERVISION              800. HRS/YR     $17.20/HR               13800. (D)
     MATERIALS                                                        114800. (E)
     SUPPLIES                                                          27900. (F)
     WATER TREATMENT                                                       0.
     SOLID WASTE
       DISPOSAL              6193. TON/YR     $ 8.25/TON               51100.

        DIRECT OPERATING COST                                         265000.

        PAYROLL OVERHEAD =20.0% OF A+B+C+D                             14200.
        PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                          107000.
        TOTAL OPERATING COST                                          386200.
        OPERATING COST IN DOLLARS PER TON   PRODUCTION                    .14
        OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED            124.72
        OPERATING COST AS PERCENT OF CAPITAL COST                         9.1
        INSTALLATION TIME IN WEEKS                                        52.
        ESTIMATED LIFE OF SYSTEM IN YEARS                                 20.
        KWH PER TON   CAPACITY                                            .0
        CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                    497300.
        ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)               84700.
        PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                 84700.
        TOTAL ANNUALIZED COST - RETROFIT                             1052900.
                              - NEW                                   898900.
```

```
GENERAL INFORMATION:
                                                              UNITS    OPTION
     PPSES:  503.   QUENCHING - CLEAN WATER                  COKE        4

     CAPACITY:             2.834 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:    1.700000 LBS/TON COAL
          ALLOWABLE:   .034000 LBS/TON COAL   EFFICIENCY:  98.0%
                       15.71   LBS/HR

     BSO
          LOAD IN:     .001700 LBS/TON COAL
          ALLOWABLE:   .000017 LBS/TON COAL   EFFICIENCY:  99.0%
                          .01  LBS/HR

     BAP
          LOAD IN:     .000140 LBS/TON COAL
          ALLOWABLE:   .000001 LBS/TON COAL   EFFICIENCY:  99.0%
                          .00  LBS/HR

     BENZENE
          LOAD IN:     .000030 LBS/TON COAL
          ALLOWABLE:   .000000 LBS/TON COAL   EFFICIENCY:  99.0%
                          .00  LBS/HR

     DUST COLLECTED PER DAY:       9.2 TONS(DRY)

     TEMP OUT OF PROCESS:         200. F
     EXHAUST TEMPERATURE:         200. F

     SCFM FLOW:  549000.   AT      70. F
     ACFM FLOW:  683000.   AT     200. F

     L/G RATIO:                     .0
     PROCESS WATER FLOW:           0. GPM
     COOLING WATER FLOW:           0. GPM
     SUSPENDED SOLIDS OUT:         0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                      UNITS    OPTION
     PPSES:  503.   QUENCHING - CLEAN WATER           COKE        4


     CONTROL SYSTEM CONFIGURATION:

          DRY QUENCHING


     FEET OF ADDITIONAL DUCT:             0.     DIAMETER: 15.
     TOTAL PRESSURE DROP:                 0. INCHES
     0 FANS @     0. HP EACH       SPARE FAN CAPACITY:    0.%
     OPERATING HOURS AT FULL HP:       8760.
     OPERATING HOURS AT REDUCED HP:       0.
     STACK HEIGHT:                        0.     DIAMETER:  0.
     NO. OF OVENS                        60.
     OVEN HEIGHT                          6.0 METERS
     OVEN VOLUME                       1348.  CUBIC FEET
     TONS COKE/PUSH                      24.
     AVG. COKING TIME,HRS.               17.5
     NO. CYCLES/DAY                      82.
     BULK DENSITY                        50.  LBS/CUBIC FT.
     YIELD                                .70
     TONS COAL/YEAR                 4047868.
```

```
CAPITAL COST:
                                                         UNITS   OPTION
     PPSES:  503.   QUENCHING - CLEAN WATER              COKE       4

     CAPACITY:            2.834 MILLION TONS/YEAR

     TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.)

             CATEGORY                                 COST IN DOLLARS

                        *** DIRECT  COST ***
             EQUIPMENT OR MATERIAL               9365400.
             INSTRUMENTATION                           0.
             PIPING                                    0.
             ELECTRICAL                                0.
             FOUNDATIONS                               0.
             STRUCTURAL                                0.
             SITE WORK                                 0.
             INSULATION                                0.
             PROTECTIVE COATING                        0.
             BUILDINGS                                 0.
             EQUIPMENT/MATERIAL LABOR            4495300.
                 DIRECT COST SUBTOTAL                        13860700.

                       *** INDIRECT  COST ***
             FIELD OVERHEAD                      2409500.
             CONTRACTORS FEE                     1591300.
             ENGINEERING                          476500.
             FREIGHT                                   0.
             OFFSITE WORK                         404600.
             TAXES                                449500.
             SHAKEDOWN                            674300.
             SPARES                                71900.
             CONTINGENCY                         4890900.
                 INDIRECT COST SUBTOTAL                      10968500.

                 INTEREST DURING INSTALLATION                 3103700.

                 TOTAL COST                                  27932900.

                 TOTAL COST WITH RETROFIT                    30726200.
```

```
OPERATING COST:
                                                      UNITS    OPTION
        PPSES:  503.   QUENCHING - CLEAN WATER        COKE       4

        CAPACITY:           2.834 MILLION TONS/YEAR

        CATEGORY                 QUANTITY         RATE                  ANNUAL COST ($)

                                      *** UTILITIES ***

        WATER                       0. MGAL/YR     $  .1595/1000 GAL             0.
        ELECTRICITY          22668064. KWH/YR      $  .0266/KWH             603400.
        STEAM                       0. MLBS/YR     $ 4.0920/MLBS                 0.
        FUEL                        0. GAL/YR      $  .4180/GAL                  0.


                                 *** OPERATING LABOR ***

        DIRECT                   8760. HRS/YR      $14.34/HR                125700. (A)
        SUPERVISION              1752. HRS/YR      $17.20/HR                 30100. (B)


                               *** MAINTENANCE & SUPPLIES ***

        DIRECT LABOR            62337. HRS/YR      $14.34/HR                894200. (C)
        SUPERVISION             12467. HRS/YR      $17.20/HR                214500. (D)
        MATERIALS                                                           447100. (E)
        SUPPLIES                                                            233400. (F)
        WATER TREATMENT                                                          0.
        SOLID WASTE
          DISPOSAL               3372. TON/YR      $ 8.25/TON                27800.

           DIRECT OPERATING COST                                           2576200.

           PAYROLL OVERHEAD =20.0% OF A+B+C+D                               252900.
           PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                             972500.
           TOTAL OPERATING COST                                            3801600.
           OPERATING COST IN DOLLARS PER TON   PRODUCTION                     1.34
           OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED             1127.44
           OPERATING COST AS PERCENT OF CAPITAL COST                         12.4
           INSTALLATION TIME IN WEEKS                                       130.
           ESTIMATED LIFE OF SYSTEM IN YEARS                                 25.
           KWH PER TON    CAPACITY                                           8.0
           CAPITAL RECOVERY (11.02% OF TOTAL CAPITAL)                      3385000.
           ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                 614500.
           PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                   614500.
           TOTAL ANNUALIZED COST - RETROFIT                                8415600.
                                 - NEW                                     7996300.
```

```
GENERAL INFORMATION:
                                                  UNITS    OPTION
    PPSES:  504.   DOORS                           COKE       2

    CAPACITY:              .708 MILLION TONS/YEAR

    PARTICULATE
         LOAD IN:      .500000 LBS/TON COAL
         ALLOWABLE:    .200000 LBS/TON COAL   EFFICIENCY:  60.0%
                         23.10 LBS/HR

    BSO
         LOAD IN:      .500000 LBS/TON COAL
         ALLOWABLE:    .200000 LBS/TON COAL   EFFICIENCY:  60.0%
                         23.10 LBS/HR

    BAP
         LOAD IN:      .003000 LBS/TON COAL
         ALLOWABLE:    .001200 LBS/TON COAL   EFFICIENCY:  60.0%
                           .14 LBS/HR

    BENZENE
         LOAD IN:      .010000 LBS/TON COAL
         ALLOWABLE:    .004000 LBS/TON COAL   EFFICIENCY:  60.0%
                           .46 LBS/HR

    DUST COLLECTED PER DAY:          .4 TONS(DRY)

    TEMP OUT OF PROCESS:          120. F
    EXHAUST TEMPERATURE:          120. F

    SCFM FLOW:         0.    AT    70. F
    ACFM FLOW:         0.    AT   120. F

    L/G RATIO:                       .0
    PROCESS WATER FLOW:             0. GPM
    COOLING WATER FLOW:             0. GPM
    SUSPENDED SOLIDS OUT:           0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                      UNITS    OPTION
      PPSES:  504.   DOORS                            COKE       2


      CONTROL SYSTEM CONFIGURATION:

            COKE OVEN DOOR CLEAN & MAINT


      FEET OF ADDITIONAL DUCT:              0.    DIAMETER:  0.
      TOTAL PRESSURE DROP:                  0. INCHES
      0 FANS @    0. HP EACH         SPARE FAN CAPACITY:   0.%
      OPERATING HOURS AT FULL HP:       8760.
      OPERATING HOURS AT REDUCED HP:        0.
      STACK HEIGHT:                         0.    DIAMETER:  0.
      NO. OF OVENS                         60.
      OVEN HEIGHT                           6.0 METERS
      OVEN VOLUME                        1348.  CUBIC FEET
      TONS COKE/PUSH                       24.
      AVG. COKING TIME,HRS.                17.5
      NO. CYCLES/DAY                       82.
      BULK DENSITY                         50.  LBS/CUBIC FT.
      YIELD                                 .70
      TONS COAL/YEAR                  1011967.
```

```
OPERATING COST:
                                                   UNITS    OPTION
    PPSES:  504.   DOORS                           COKE       2

    CAPACITY:           .708 MILLION TONS/YEAR

    CATEGORY             QUANTITY        RATE                  ANNUAL COST ($)

                               *** UTILITIES ***

    WATER                     0. MGAL/YR   $  .1595/1000 GAL          0.
    ELECTRICITY               0. KWH/YR    $  .0266/KWH               0.
    STEAM                     0. MLBS/YR   $ 4.0920/MLBS              0.
    FUEL                      0. GAL/YR    $  .4180/GAL               0.

                             *** OPERATING LABOR ***

    DIRECT                    0. HRS/YR    $14.34/HR                  0. (A)
    SUPERVISION               0. HRS/YR    $17.20/HR                  0. (B)

                         *** MAINTENANCE & SUPPLIES ***

    DIRECT LABOR          17520. HRS/YR    $14.34/HR             251300. (C)
    SUPERVISION            3504. HRS/YR    $17.20/HR              60300. (D)
    MATERIALS                                                    125400. (E)
    SUPPLIES                                                      58000. (F)
    WATER TREATMENT                                                   0.
    SOLID WASTE
      DISPOSAL                0. TON/YR    $ 8.25/TON                 0.

         DIRECT OPERATING COST                                   495000.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                       62300.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                    247500.
         TOTAL OPERATING COST                                    804800.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION             1.14
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED     5301.89
         OPERATING COST AS PERCENT OF CAPITAL COST                    .0
         INSTALLATION TIME IN WEEKS                                   8.
         ESTIMATED LIFE OF SYSTEM IN YEARS                           99.
         KWH PER TON    CAPACITY                                      .0
         CAPITAL RECOVERY (10.00% OF TOTAL CAPITAL)                   0.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)             0.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)               0.
         TOTAL ANNUALIZED COST - RETROFIT                        804800.
                               - NEW                             804800.
```

```
GENERAL INFORMATION:
                                                  UNITS    OPTION
    PPSES:  504.   DOORS                          COKE        3

    CAPACITY:           .708 MILLION TONS/YEAR

    PARTICULATE
          LOAD IN:     .500000 LBS/TON COAL
          ALLOWABLE:   .100000 LBS/TON COAL   EFFICIENCY:  80.0%
                        11.55  LBS/HR

    BSO
          LOAD IN:     .500000 LBS/TON COAL
          ALLOWABLE:   .100000 LBS/TON COAL   EFFICIENCY:  80.0%
                        11.55  LBS/HR

    BAP
          LOAD IN:     .003000 LBS/TON COAL
          ALLOWABLE:   .000600 LBS/TON COAL   EFFICIENCY:  80.0%
                          .07  LBS/HR

    BENZENE
          LOAD IN:     .010000 LBS/TON COAL
          ALLOWABLE:   .002000 LBS/TON COAL   EFFICIENCY:  80.0%
                          .23  LBS/HR

    DUST COLLECTED PER DAY:         .6 TONS(DRY)

    TEMP OUT OF PROCESS:          120. F
    EXHAUST TEMPERATURE:          120. F

    SCFM FLOW:        0.    AT     70. F
    ACFM FLOW:        0.    AT    120. F

    L/G RATIO:                       .0
    PROCESS WATER FLOW:             0. GPM
    COOLING WATER FLOW:             0. GPM
    SUSPENDED SOLIDS OUT:           0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                            UNITS    OPTION
    PPSES:  504.   DOORS                                    COKE        3


    CONTROL SYSTEM CONFIGURATION:

          COKE OVEN DOOR CLEAN & MAINT

    FEET OF ADDITIONAL DUCT:              0.     DIAMETER:  0.
    TOTAL PRESSURE DROP:                  0. INCHES
    0 FANS @     0. HP EACH        SPARE FAN CAPACITY:   0.%
    OPERATING HOURS AT FULL HP:       8760.
    OPERATING HOURS AT REDUCED HP:       0.
    STACK HEIGHT:                         0.     DIAMETER:  0.
    NO. OF OVENS                         60.
    OVEN HEIGHT                           6.0 METERS
    OVEN VOLUME                        1348.  CUBIC FEET
    TONS COKE/PUSH                       24.
    AVG. COKING TIME,HRS.                17.5
    NO. CYCLES/DAY                       82.
    BULK DENSITY                         50.  LBS/CUBIC FT.
    YIELD                                 .70
    TONS COAL/YEAR                  1011967.
```

```
CAPITAL COST:
                                                    UNITS    OPTION
     PPSES:  504.   DOORS                           COKE       3

     CAPACITY:          .708 MILLION TONS/YEAR

     TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4078 COST.

          CATEGORY                            COST IN DOLLARS

                  *** DIRECT  COST ***
          EQUIPMENT OR MATERIAL               251900.
          INSTRUMENTATION                          0.
          PIPING                                   0.
          ELECTRICAL                               0.
          FOUNDATIONS                              0.
          STRUCTURAL                               0.
          SITE WORK                                0.
          INSULATION                               0.
          PROTECTIVE COATING                       0.
          BUILDINGS                                0.
          EQUIPMENT/MATERIAL LABOR             13300.
               DIRECT COST SUBTOTAL                       265200.

                  *** INDIRECT  COST ***
          FIELD OVERHEAD                        7000.
          CONTRACTORS FEE                       3000.
          ENGINEERING                          17500.
          FREIGHT                               1500.
          OFFSITE WORK                             0.
          TAXES                                12500.
          SHAKEDOWN                             2300.
          SPARES                               12000.
          CONTINGENCY                          63900.
               INDIRECT COST SUBTOTAL                     119700.

               INTEREST DURING INSTALLATION                29600.

               TOTAL COST                                 414500.

               TOTAL COST WITH RETROFIT                   414500.
```

```
OPERATING COST:
                                                    UNITS    OPTION
     PPSES:  504.   DOORS                           COKE       3

     CAPACITY:            .708 MILLION TONS/YEAR

     CATEGORY                 QUANTITY         RATE                  ANNUAL COST ($

                               *** UTILITIES ***

     WATER                      0. MGAL/YR    $  .1595/1000 GAL              0.
     ELECTRICITY                0. KWH/YR     $  .0266/KWH                   0.
     STEAM                      0. MLBS/YR    $ 4.0920/MLBS                  0.
     FUEL                       0. GAL/YR     $  .4180/GAL                   0.

                             *** OPERATING LABOR ***

     DIRECT                 17520. HRS/YR     $14.34/HR                251300. (A)
     SUPERVISION             3504. HRS/YR     $17.20/HR                 60300. (B)

                          *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR            4500. HRS/YR     $14.34/HR                 64500. (C)
     SUPERVISION              900. HRS/YR     $17.20/HR                 15500. (D)
     MATERIALS                                                          82300. (E)
     SUPPLIES                                                           16800. (F)
     WATER TREATMENT                                                        0.
     SOLID WASTE
       DISPOSAL                 0. TON/YR     $ 8.25/TON                    0.

        DIRECT OPERATING COST                                          490700.

        PAYROLL OVERHEAD =20.0% OF A+B+C+D                              78300.
        PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                           245400.
        TOTAL OPERATING COST                                           814400.
        OPERATING COST IN DOLLARS PER TON   PRODUCTION                    1.15
        OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED            4023.85
        OPERATING COST AS PERCENT OF CAPITAL COST                        196.5
        INSTALLATION TIME IN WEEKS                                         80.
        ESTIMATED LIFE OF SYSTEM IN YEARS                                  25.
        KWH PER TON    CAPACITY                                             .0
        CAPITAL RECOVERY (11.02% OF TOTAL CAPITAL)                      45700.
        ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                 8300.
        PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                   8300.
        TOTAL ANNUALIZED COST - RETROFIT                               876700.
                              - NEW                                    876700.
```

```
GENERAL INFORMATION:
                                                    UNITS    OPTION
    PPSES:  504.    DOORS                            COKE       4

    CAPACITY:               .708 MILLION TONS/YEAR

    PARTICULATE
         LOAD IN:      .500000 LBS/TON COAL
         ALLOWABLE:    .057500 LBS/TON COAL   EFFICIENCY:  88.5%
                          6.99 LBS/HR

    BSO
         LOAD IN:      .500000 LBS/TON COAL
         ALLOWABLE:    .110000 LBS/TON COAL   EFFICIENCY:  78.0%
                         13.38 LBS/HR

    BAP
         LOAD IN:      .003000 LBS/TON COAL
         ALLOWABLE:    .000660 LBS/TON COAL   EFFICIENCY:  78.0%
                           .08 LBS/HR

    BENZENE
         LOAD IN:      .010000 LBS/TON COAL
         ALLOWABLE:    .003500 LBS/TON COAL   EFFICIENCY:  65.0%
                           .43 LBS/HR

    DUST COLLECTED PER DAY:          .6 TONS(DRY)

    TEMP OUT OF PROCESS:          120. F
    EXHAUST TEMPERATURE:          100. F

    SCFM FLOW:   20000.   AT       70. F
    ACFM FLOW:   22000.   AT      100. F

    L/G RATIO:                      8.0
    PROCESS WATER FLOW:           160. GPM
    COOLING WATER FLOW:             0. GPM
    SUSPENDED SOLIDS OUT:         532. MG/L     %SOLIDS:     .1
```

```
GENERAL INFORMATION:
                                                  UNITS   OPTION
    PPSES:  504.   DOORS                           COKE      4


    CONTROL SYSTEM CONFIGURATION:

          VENTURI SCRUBBER
          MIST ELIMINATOR
          FAN AND DRIVE
          DUCTWORK
          STACK
          CANOPY HOOD
          WASTEWATER RECYCLE SYSTEM
          DAMPERS
          WASTE WATER RETURN SYSTEM
          WATER PUMPING SYSTEM
          FAN AND DRIVE ELECTRICAL
          COKE OVEN DOOR CLEAN & MAINT

    FEET OF ADDITIONAL DUCT:        630.    DIAMETER:  3.
    TOTAL PRESSURE DROP:             35. INCHES
    2 FANS @  202. HP EACH        SPARE FAN CAPACITY: 100.%
    OPERATING HOURS AT FULL HP:    8322.
    OPERATING HOURS AT REDUCED HP:    0.
    STACK HEIGHT:                   100.    DIAMETER:  3.
    NO. OF OVENS                     60.
    HOOD SIZE:                       16. SQ.FT.
    OVEN HEIGHT                       6.0 METERS
    OVEN VOLUME                    1348.  CUBIC FEET
    TONS COKE/PUSH                   24.
    AVG. COKING TIME,HRS.            17.5
    NO. CYCLES/DAY                   82.
    BULK DENSITY                     50.  LBS/CUBIC FT.
    YIELD                              .70
    TONS COAL/YEAR              1011967.
```

```
CAPITAL COST:
                                                      UNITS    OPTION
    PPSES:  504.   DOORS                              COKE       4

    CAPACITY:              .708 MILLION TONS/YEAR

    TOTAL COST      (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST

        CATEGORY                             COST IN DOLLARS

                 *** DIRECT  COST ***
        EQUIPMENT OR MATERIAL                  441400.
        INSTRUMENTATION                         51900.
        PIPING                                  67100.
        ELECTRICAL                              99000.
        FOUNDATIONS                             22600.
        STRUCTURAL                              83600.
        SITE WORK                                3800.
        INSULATION                               7700.
        PROTECTIVE COATING                      12900.
        BUILDINGS                               10800.
        EQUIPMENT/MATERIAL LABOR               156700.
             DIRECT COST SUBTOTAL                            957500.

                *** INDIRECT  COST ***
        FIELD OVERHEAD                         138100.
        CONTRACTORS FEE                         66900.
        ENGINEERING                            138300.
        FREIGHT                                 41900.
        OFFSITE WORK                            20400.
        TAXES                                   38000.
        SHAKEDOWN                               37700.
        SPARES                                  34500.
        CONTINGENCY                            333200.
             INDIRECT COST SUBTOTAL                          849000.

             INTEREST DURING INSTALLATION                    131900.

             TOTAL COST                                     1938400.

             TOTAL COST WITH RETROFIT                       2363000.
```

```
OPERATING COST:
                                                    UNITS    OPTION
  PPSES:  504.    DOORS                              COKE       4

  CAPACITY:            .708 MILLION TONS/YEAR

  CATEGORY             QUANTITY          RATE                   ANNUAL COST ($

                               *** UTILITIES ***

  WATER                 15978. MGAL/YR    $  .1595/1000 GAL          2500.
  ELECTRICITY         1332553. KWH/YR     $  .0266/KWH              35500.
  STEAM                     0. MLBS/YR    $ 4.0920/MLBS                 0.
  FUEL                      0. GAL/YR     $  .4180/GAL                  0.


                            *** OPERATING LABOR ***

  DIRECT                 8760. HRS/YR     $14.34/HR               125700. (A
  SUPERVISION            1752. HRS/YR     $17.20/HR                30100. (B)


                          *** MAINTENANCE & SUPPLIES ***

  DIRECT LABOR          33977. HRS/YR     $14.34/HR               487400. (C
  SUPERVISION            6795. HRS/YR     $17.20/HR               116900. (D
  MATERIALS                                                       236400. (E)
  SUPPLIES                                                        128300. (F
  WATER TREATMENT                                                      0.
  SOLID WASTE
    DISPOSAL              448. TON/YR     $ 8.25/TON                 3700.

     DIRECT OPERATING COST                                       1166500.

     PAYROLL OVERHEAD =20.0% OF A+B+C+D                           152000.
     PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                         562400.
     TOTAL OPERATING COST                                        1880900.
     OPERATING COST IN DOLLARS PER TON   PRODUCTION                  2.66
     OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED          8400.71
     OPERATING COST AS PERCENT OF CAPITAL COST                       79.6
     INSTALLATION TIME IN WEEKS                                     104.
     ESTIMATED LIFE OF SYSTEM IN YEARS                               15.
     KWH PER TON    CAPACITY                                          1.9
     CAPITAL RECOVERY (13.15% OF TOTAL CAPITAL)                  310700.
     ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)             47300.
     PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)               47300.
     TOTAL ANNUALIZED COST - RETROFIT                           2286200.
                           - NEW                                2213300.
```

```
GENERAL INFORMATION:
                                                          UNITS    OPTION
     PPSES:  504.   DOORS                                  COKE       5

     CAPACITY:            .708 MILLION TONS/YEAR

     PARTICULATE
           LOAD IN:     .500000 LBS/TON COAL
           ALLOWABLE:   .033500 LBS/TON COAL    EFFICIENCY:  93.3%
                          4.07  LBS/HR

     BSO
           LOAD IN:     .500000 LBS/TON COAL
           ALLOWABLE:   .081000 LBS/TON COAL    EFFICIENCY:  83.8%
                          9.85  LBS/HR

     BAP
           LOAD IN:     .003000 LBS/TON COAL
           ALLOWABLE:   .000486 LBS/TON COAL    EFFICIENCY:  83.8%
                           .06  LBS/HR

     BENZENE
           LOAD IN:     .010000 LBS/TON COAL
           ALLOWABLE:   .002800 LBS/TON COAL    EFFICIENCY:  72.0%
                           .34  LBS/HR

     DUST COLLECTED PER DAY:         .6 TONS(DRY)

     TEMP OUT OF PROCESS:         120. F
     EXHAUST TEMPERATURE:         100. F

     SCFM FLOW:   26000.   AT      70. F
     ACFM FLOW:   27000.   AT     100. F

     L/G RATIO:                     8.0
     PROCESS WATER FLOW:          208. GPM
     COOLING WATER FLOW:            0. GPM
     SUSPENDED SOLIDS OUT:        409. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                UNITS   OPTION
    PPSES:  504.   DOORS                        COKE      5


    CONTROL SYSTEM CONFIGURATION:

         VENTURI SCRUBBER
         MIST ELIMINATOR
         FAN AND DRIVE
         DUCTWORK
         STACK
         CANOPY HOOD
         WASTEWATER RECYCLE SYSTEM
         DAMPERS
         WASTE WATER RETURN SYSTEM
         WATER PUMPING SYSTEM
         FAN AND DRIVE ELECTRICAL
         COKE OVEN DOOR CLEAN & MAINT


    FEET OF ADDITIONAL DUCT:          630.    DIAMETER:  3.
    TOTAL PRESSURE DROP:               65. INCHES
    2 FANS @  460. HP EACH        SPARE FAN CAPACITY: 100.%
    OPERATING HOURS AT FULL HP:     8322.
    OPERATING HOURS AT REDUCED HP:     0.
    STACK HEIGHT:                     100.    DIAMETER:  3.
    NO. OF OVENS                       60.
    HOOD SIZE:                         16. SQ.FT.
    OVEN HEIGHT                         6.0 METERS
    OVEN VOLUME                      1348.  CUBIC FEET
    TONS COKE/PUSH                     24.
    AVG. COKING TIME,HRS.              17.5
    NO. CYCLES/DAY                     82.
    BULK DENSITY                       50.  LBS/CUBIC FT.
    YIELD                                .70
    TONS COAL/YEAR                1011967.
```

```
CAPITAL COST:
                                                      UNITS   OPTION
     PPSES: 504.   DOORS                              COKE      5

     CAPACITY:          .708 MILLION TONS/YEAR

     TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST

           CATEGORY                             COST IN DOLLARS

                     *** DIRECT  COST ***
           EQUIPMENT OR MATERIAL                551400.
           INSTRUMENTATION                       51900.
           PIPING                                75700.
           ELECTRICAL                           110300.
           FOUNDATIONS                           27000.
           STRUCTURAL                            87900.
           SITE WORK                              4200.
           INSULATION                             8600.
           PROTECTIVE COATING                    14000.
           BUILDINGS                             12200.
           EQUIPMENT/MATERIAL LABOR             177900.
              DIRECT COST SUBTOTAL                          1121100.

                     *** INDIRECT  COST ***
           FIELD OVERHEAD                       154800.
           CONTRACTORS FEE                       75700.
           ENGINEERING                          148900.
           FREIGHT                               46100.
           OFFSITE WORK                          23200.
           TAXES                                 43800.
           SHAKEDOWN                             43900.
           SPARES                                39000.
           CONTINGENCY                          378400.
              INDIRECT COST SUBTOTAL                         953800.

              INTEREST DURING INSTALLATION                   150100.

              TOTAL COST                                    2225000.

              TOTAL COST WITH RETROFIT                      2696700.
```

```
OPERATING COST:
                                                        UNITS   OPTION
    PPSES:  504.   DOORS                                COKE       5

    CAPACITY:              .708 MILLION TONS/YEAR

    CATEGORY                 QUANTITY          RATE                 ANNUAL COST (

                              *** UTILITIES ***

    WATER                     20772. MGAL/YR    $  .1595/1000 GAL          3300.
    ELECTRICITY             3026942. KWH/YR     $  .0266/KWH              80600.
    STEAM                         0. MLBS/YR    $ 4.0920/MLBS                 0.
    FUEL                          0. GAL/YR     $  .4180/GAL                  0.


                           *** OPERATING LABOR ***

    DIRECT                     8760. HRS/YR     $14.34/HR                125700. (
    SUPERVISION                1752. HRS/YR     $17.20/HR                 30100. (


                        *** MAINTENANCE & SUPPLIES ***

    DIRECT LABOR              33977. HRS/YR     $14.34/HR                487400. (C
    SUPERVISION                6795. HRS/YR     $17.20/HR                116900. (
    MATERIALS                                                            236400. (
    SUPPLIES                                                             128800. (F
    WATER TREATMENT                                                           0.
    SOLID WASTE
      DISPOSAL                  472. TON/YR     $ 8.25/TON                 3900.

        DIRECT OPERATING COST                                           1213100.

        PAYROLL OVERHEAD =20.0% OF A+B+C+D                               152000.
        PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                             562700.
        TOTAL OPERATING COST                                            1927800.
        OPERATING COST IN DOLLARS PER TON - PRODUCTION                      2.72
        OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED              8167.21
        OPERATING COST AS PERCENT OF CAPITAL COST                           71.5
        INSTALLATION TIME IN WEEKS                                         104.
        ESTIMATED LIFE OF SYSTEM IN YEARS                                   15.
        KWH PER TON    CAPACITY                                              4.3
        CAPITAL RECOVERY (13.15% OF TOTAL CAPITAL)                       354500.
        ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                  53900.
        PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                    53900.
        TOTAL ANNUALIZED COST - RETROFIT                                2390100.
                              - NEW                                     2309300.
```

Reproduced from best available copy.

```
GENERAL INFORMATION:
                                                      UNITS   OPTION
         PPSES:  504.   DOORS                          COKE       6

         CAPACITY:            .708 MILLION TONS/YEAR

         PARTICULATE
              LOAD IN:     .500000 LBS/TON COAL
              ALLOWABLE:   .057500 LBS/TON COAL   EFFICIENCY:  88.5%
                              6.99  LBS/HR

         BSO
              LOAD IN:     .500000 LBS/TON COAL
              ALLOWABLE:   .110000 LBS/TON COAL   EFFICIENCY:  78.0%
                             13.38  LBS/HR

         BAP
              LOAD IN:     .003000 LBS/TON COAL
              ALLOWABLE:   .000660 LBS/TON COAL   EFFICIENCY:  78.0%
                               .06  LBS/HR

         BENZENE
              LOAD IN:     .010000 LBS/TON COAL
              ALLOWABLE:   .003500 LBS/TON COAL   EFFICIENCY:  65.0%
                               .43  LBS/HR

         DUST COLLECTED PER DAY:           .6 TONS(DRY)

         TEMP OUT OF PROCESS:          120. F
         EXHAUST TEMPERATURE:          100. F

         SCFM FLOW:    10000.    AT     70. F
         ACFM FLOW:    11000.    AT    100. F

         L/G RATIO:                      8.0
         PROCESS WATER FLOW:            80. GPM
         COOLING WATER FLOW:             0. GPM
         SUSPENDED SOLIDS OUT:        1064. MG/L      %SOLIDS:     .1
```

```
GENERAL INFORMATION:
                                                                    UNITS    OPTION
      PPSES:  504.    DOORS                                          COKE       6


      CONTROL SYSTEM CONFIGURATION:

             VENTURI SCRUBBER
             MIST ELIMINATOR
             FAN AND DRIVE
             DUCTWORK
             STACK
             CANOPY HOOD
             WASTEWATER RECYCLE SYSTEM
             DAMPERS
             WASTE WATER RETURN SYSTEM
             WATER PUMPING SYSTEM
             FAN AND DRIVE ELECTRICAL
             COKE OVEN DOOR CLEAN & MAINT


      FEET OF ADDITIONAL DUCT:             350.     DIAMETER:  2.
      TOTAL PRESSURE DROP:                  35. INCHES
      2 FANS @  101. HP EACH          SPARE FAN CAPACITY: 100.%
      OPERATING HOURS AT FULL HP:        8322.
      OPERATING HOURS AT REDUCED HP:        0.
      STACK HEIGHT:                        100.     DIAMETER:  2.
      NO. OF OVENS                          60.
      HOOD SIZE:                            16. SQ.FT.
      OVEN HEIGHT                            6.0 METERS
      OVEN VOLUME                         1348.  CUBIC FEET
      TONS COKE/PUSH                        24.
      AVG. COKING TIME,HRS.                 17.5
      NO. CYCLES/DAY                        82.
      BULK DENSITY                          50.  LBS/CUBIC FT.
      YIELD                                   .70
      TONS COAL/YEAR                   1011967.
```

```
CAPITAL COST:
                                                         UNITS   OPTION
      PPSES:  504.   DOORS                               COKE       6

      CAPACITY:                .708 MILLION TONS/YEAR

      TOTAL COST      (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4078 COST

            CATEGORY                                COST IN DOLLARS

                         *** DIRECT  COST ***
            EQUIPMENT OR MATERIAL                   270300.
            INSTRUMENTATION                          51900.
            PIPING                                   48100.
            ELECTRICAL                               74300.
            FOUNDATIONS                              16400.
            STRUCTURAL                               48100.
            SITE WORK                                 3000.
            INSULATION                                5800.
            PROTECTIVE COATING                        8000.
            BUILDINGS                                 7800.
            EQUIPMENT/MATERIAL LABOR                102900.
                 DIRECT COST SUBTOTAL                          636600.

                        *** INDIRECT  COST ***
            FIELD OVERHEAD                           95000.
            CONTRACTORS FEE                          44900.
            ENGINEERING                             113400.
            FREIGHT                                  24900.
            OFFSITE WORK                             14600.
            TAXES                                    24500.
            SHAKEDOWN                                27500.
            SPARES                                   25100.
            CONTINGENCY                             220700.
                 INDIRECT COST SUBTOTAL                        590600.

                 INTEREST DURING INSTALLATION                   92500.

                 TOTAL COST                                   1319700.

                 TOTAL COST WITH RETROFIT                     1583100.
```

```
OPERATING COST:
                                                          UNITS   OPTION
     PPSES:  504.   DOORS                                 COKE      6

     CAPACITY:            .708 MILLION TONS/YEAR

     CATEGORY                 QUANTITY          RATE                  ANNUAL COST (

                                   *** UTILITIES ***

     WATER                  7989. MGAL/YR     $  .1595/1000 GAL          1300.
     ELECTRICITY          666276. KWH/YR      $  .0266/KWH              17700.
     STEAM                     0. MLBS/YR     $ 4.0920/MLBS                 0.
     FUEL                      0. GAL/YR      $  .4180/GAL                  0.


                                *** OPERATING LABOR ***

     DIRECT                 8760. HRS/YR      $14.34/HR                125700. (A
     SUPERVISION            1752. HRS/YR      $17.20/HR                 30100. (B


                             *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR          29937. HRS/YR      $14.34/HR                429400. (C
     SUPERVISION            5987. HRS/YR      $17.20/HR                103000. (D
     MATERIALS                                                         209100. (E
     SUPPLIES                                                          112300. (F
     WATER TREATMENT                                                        0.
     SOLID WASTE
       DISPOSAL              448. TON/YR      $ 8.25/TON                 3700.

          DIRECT OPERATING COST                                       1032300.

          PAYROLL OVERHEAD =20.0% OF A+B+C+D                           137600.
          PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                         504800.
          TOTAL OPERATING COST                                        1674700.
          OPERATING COST IN DOLLARS PER TON   PRODUCTION                  2.36
          OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED          7479.75
          OPERATING COST AS PERCENT OF CAPITAL COST                      105.8
          INSTALLATION TIME IN WEEKS                                     104.
          ESTIMATED LIFE OF SYSTEM IN YEARS                               15.
          KWH PER TON    CAPACITY                                           .9
          CAPITAL RECOVERY (13.15% OF TOTAL CAPITAL)                  208100.
          ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)             31700.
          PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)               31700.
          TOTAL ANNUALIZED COST - RETROFIT                            1946200.
                                - NEW                                 1901000.
```

```
GENERAL INFORMATION:
                                                              UNITS    OPTION
          PPSES:  504.   DOORS                                 COKE       7

          CAPACITY:              .708 MILLION TONS/YEAR

          PARTICULATE
                LOAD IN:     .500000 LBS/TON COAL
                ALLOWABLE:  .033500 LBS/TON COAL    EFFICIENCY:  93.3%
                               4.07  LBS/HR

          BSO
                LOAD IN:     .500000 LBS/TON COAL
                ALLOWABLE:  .081000 LBS/TON COAL    EFFICIENCY:  83.8%
                               9.85  LBS/HR

          BAP
                LOAD IN:     .003000 LBS/TON COAL
                ALLOWABLE:  .000486 LBS/TON COAL    EFFICIENCY:  83.8%
                                .06  LBS/HR

          BENZENE
                LOAD IN:     .010000 LBS/TON COAL
                ALLOWABLE:  .002800 LBS/TON COAL    EFFICIENCY:  72.0%
                                .34  LBS/HR

          DUST COLLECTED PER DAY:         .6 TONS(DRY)

          TEMP OUT OF PROCESS:          120. F
          EXHAUST TEMPERATURE:          100. F

          SCFM FLOW:   13000.   AT     70. F
          ACFM FLOW:   14000.   AT    100. F

          L/G RATIO:                      8.0
          PROCESS WATER FLOW:           104. GPM
          COOLING WATER FLOW:             0. GPM
          SUSPENDED SOLIDS OUT:         818. MG/L     %SOLIDS:     .1
```

Reproduced from best available copy.

```
GENERAL INFORMATION:
                                                   UNITS    OPTION
     PPSES:  504.   DOORS                          COKE        7


     CONTROL SYSTEM CONFIGURATION:

          VENTURI SCRUBBER
          MIST ELIMINATOR
          FAN AND DRIVE
          DUCTWORK
          STACK
          CANOPY HOOD
          WASTEWATER RECYCLE SYSTEM
          DAMPERS
          WASTE WATER RETURN SYSTEM
          WATER PUMPING SYSTEM
          FAN AND DRIVE ELECTRICAL
          COKE OVEN DOOR CLEAN & MAINT


     FEET OF ADDITIONAL DUCT:            350.    DIAMETER:  2.
     TOTAL PRESSURE DROP:                 65. INCHES
     2 FANS @  239. HP EACH          SPARE FAN CAPACITY: 100.%
     OPERATING HOURS AT FULL HP:        8322.
     OPERATING HOURS AT REDUCED HP:        0.
     STACK HEIGHT:                       100.    DIAMETER:  2.
     NO. OF OVENS                         60.
     HOOD SIZE:                           16. SQ.FT.
     OVEN HEIGHT                          6.0 METERS
     OVEN VOLUME                        1348.  CUBIC FEET
     TONS COKE/PUSH                       24.
     AVG. COKING TIME,HRS.                17.5
     NO. CYCLES/DAY                       82.
     BULK DENSITY                         50.  LBS/CUBIC FT.
     YIELD                                 .70
     TONS COAL/YEAR                  1011967.
```

```
   CAPITAL COST:
                                                              UNITS    OPTION
        PPSES:  504.   DOORS                                  COKE       7

        CAPACITY:           .708 MILLION TONS/YEAR

        TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST

              CATEGORY                              COST IN DOLLARS

                          *** DIRECT  COST ***
              EQUIPMENT OR MATERIAL                 340000.
              INSTRUMENTATION                        51900.
              PIPING                                 54600.
              ELECTRICAL                             82800.
              FOUNDATIONS                            19700.
              STRUCTURAL                             51400.
              SITE WORK                               3200.
              INSULATION                              6500.
              PROTECTIVE COATING                      9000.
              BUILDINGS                               8900.
              EQUIPMENT/MATERIAL LABOR              115700.
                    DIRECT COST SUBTOTAL                           743700.

                         *** INDIRECT  COST ***
              FIELD OVERHEAD                        106500.
              CONTRACTORS FEE                        52300.
              ENGINEERING                           123000.
              FREIGHT                                27600.
              OFFSITE WORK                           17000.
              TAXES                                  29300.
              SHAKEDOWN                              32800.
              SPARES                                 29200.
              CONTINGENCY                           254300.
                    INDIRECT COST SUBTOTAL                         672000.

                    INTEREST DURING INSTALLATION                   107300.

                    TOTAL COST                                    1523000.

                    TOTAL COST WITH RETROFIT                      1818400.
```

```
OPERATING COST:
                                                             UNITS    OPTION
      PPSES:  504.   DOORS                                   COKE       7

      CAPACITY:               .708 MILLION TONS/YEAR

      CATEGORY                QUANTITY          RATE                  ANNUAL COST ($)

                                    *** UTILITIES ***

      WATER                  10386. MGAL/YR     $  .1595/1000 GAL          1700.
      ELECTRICITY          1569274. KWH/YR      $  .0266/KWH              41800.
      STEAM                      0. MLBS/YR     $ 4.0920/MLBS                 0.
      FUEL                       0. GAL/YR      $  .4180/GAL                  0.

                                *** OPERATING LABOR ***

      DIRECT                  8760. HRS/YR      $14.34/HR                125700. (A)
      SUPERVISION             1752. HRS/YR      $17.20/HR                 30100. (B)

                            *** MAINTENANCE & SUPPLIES ***

      DIRECT LABOR           30137. HRS/YR      $14.34/HR                432300. (C
      SUPERVISION             6027. HRS/YR      $17.20/HR                103700. (D)
      MATERIALS                                                          211300. (E)
      SUPPLIES                                                           113500. (F
      WATER TREATMENT                                                         0.
      SOLID WASTE
        DISPOSAL               472. TON/YR      $ 8.25/TON                 3900.

          DIRECT OPERATING COST                                         1064000.

          PAYROLL OVERHEAD =20.0% OF A+B+C+D                             138400.
          PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                           508300.
          TOTAL OPERATING COST                                          1710700.
          OPERATING COST IN DOLLARS PER TON   PRODUCTION                   2.41
          OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED           7247.46
          OPERATING COST AS PERCENT OF CAPITAL COST                        94.1
          INSTALLATION TIME IN WEEKS                                      104.
          ESTIMATED LIFE OF SYSTEM IN YEARS                                15.
          KWH PER TON    CAPACITY                                          2.2
          CAPITAL RECOVERY (13.15% OF TOTAL CAPITAL)                     239100.
          ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                36400.
          PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                  36400.
          TOTAL ANNUALIZED COST - RETROFIT                              2022600.
                                - NEW                                   1971900.
```

```
GENERAL INFORMATION:

                                                      UNITS    OPTION
     PPSES:  505.   TOPSIDE                           COKE       2

     CAPACITY:              .708 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:     .200000 LBS/TON COAL
          ALLOWABLE:   .020000 LBS/TON COAL   EFFICIENCY:  90.0%
                          2.31  LBS/HR

     BSO
          LOAD IN:     .250000 LBS/TON COAL
          ALLOWABLE:   .025000 LBS/TON COAL   EFFICIENCY:  90.0%
                          2.89  LBS/HR

     BAP
          LOAD IN:     .001000 LBS/TON COAL
          ALLOWABLE:   .000100 LBS/TON COAL   EFFICIENCY:  90.0%
                           .01  LBS/HR

     BENZENE
          LOAD IN:     .005000 LBS/TON COAL
          ALLOWABLE:   .000500 LBS/TON COAL   EFFICIENCY:  90.0%
                           .06  LBS/HR

     DUST COLLECTED PER DAY:         .2 TONS(DRY)

     TEMP OUT OF PROCESS:         120. F
     EXHAUST TEMPERATURE:         120. F

     SCFM FLOW:         0.   AT    70. F
     ACFM FLOW:         0.   AT   120. F

     L/G RATIO:                      .0
     PROCESS WATER FLOW:           0. GPM
     COOLING WATER FLOW:           0. GPM
     SUSPENDED SOLIDS OUT:         0. MG/L      %SOLIDS:    .0
```

```
GENERAL INFORMATION:
                                                        UNITS   OPTION
     PPSES:  505.   TOPSIDE                              COKE      2

     CONTROL SYSTEM CONFIGURATION:

          TOPSIDE MAINTENANCE - LEVEL 1

     FEET OF ADDITIONAL DUCT:            0.    DIAMETER:  0.
     TOTAL PRESSURE DROP:                0. INCHES
     0 FANS @    0. HP EACH       SPARE FAN CAPACITY:   0.%
     OPERATING HOURS AT FULL HP:     8760.
     OPERATING HOURS AT REDUCED HP:     0.
     STACK HEIGHT:                       0.    DIAMETER:  0.
     NO. OF OVENS                       60.
     OVEN HEIGHT                         6.0 METERS
     OVEN VOLUME                      1348.  CUBIC FEET
     TONS COKE/PUSH                     24.
     AVG. COKING TIME,HRS.              17.5
     NO. CYCLES/DAY                     82.
     BULK DENSITY                       50.  LBS/CUBIC FT.
     YIELD                                .70
     TONS COAL/YEAR                1011967.
```

```
OPERATING COST:
                                                          UNITS   OPTION
    PPSES:  505.   TOPSIDE                                 COKE      2

    CAPACITY:             .708 MILLION TONS/YEAR

    CATEGORY                  QUANTITY          RATE                 ANNUAL COST ($)

                                       *** UTILITIES ***

    WATER                        0. MGAL/YR    $  .1595/1000 GAL               0.
    ELECTRICITY                  0. KWH/YR     $  .0266/KWH                    0.
    STEAM                        0. MLBS/YR    $ 4.0920/MLBS                   0.
    FUEL                         0. GAL/YR     $  .4180/GAL                    0.

                                    *** OPERATING LABOR ***

    DIRECT                    8760. HRS/YR     $14.34/HR                  125700. (A)
    SUPERVISION               1752. HRS/YR     $17.20/HR                   30100. (B)

                                 *** MAINTENANCE & SUPPLIES ***

    DIRECT LABOR                 0. HRS/YR     $14.34/HR                       0. (C)
    SUPERVISION                  0. HRS/YR     $17.20/HR                       0. (D)
    MATERIALS                                                                  0. (E)
    SUPPLIES                                                                   0. (F)
    WATER TREATMENT                                                            0.
    SOLID WASTE
      DISPOSAL                   0. TON/YR     $ 8.25/TON                      0.

        DIRECT OPERATING COST                                             155800.

        PAYROLL OVERHEAD =20.0% OF A+B+C+D                                 31200.
        PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                               77900.
        TOTAL OPERATING COST                                              264900.
        OPERATING COST IN DOLLARS PER TON   PRODUCTION                         .37
        OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED              2908.53
        OPERATING COST AS PERCENT OF CAPITAL COST                              .0
        INSTALLATION TIME IN WEEKS                                             8.
        ESTIMATED LIFE OF SYSTEM IN YEARS                                     99.
        KWH PER TON    CAPACITY                                                .0
        CAPITAL RECOVERY (10.00% OF TOTAL CAPITAL)                             0.
        ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                       0.
        PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                         0.
        TOTAL ANNUALIZED COST - RETROFIT                                  264900.
                              - NEW                                       264900.
```

```
GENERAL INFORMATION:
                                                            UNITS    OPTION
        PPSES:  505.   TOPSIDE                               COKE       3

        CAPACITY:              .708 MILLION TONS/YEAR

        PARTICULATE
              LOAD IN:     .200000 LBS/TON COAL
              ALLOWABLE:   .010000 LBS/TON COAL    EFFICIENCY:  95.0%
                              1.16  LBS/HR

        BSO
              LOAD IN:     .250000 LBS/TON COAL
              ALLOWABLE:   .012500 LBS/TON COAL    EFFICIENCY:  95.0%
                              1.44  LBS/HR

        BAP
              LOAD IN:     .001000 LBS/TON COAL
              ALLOWABLE:   .000050 LBS/TON COAL    EFFICIENCY:  95.0%
                               .01  LBS/HR

        BENZENE
              LOAD IN:     .005000 LBS/TON COAL
              ALLOWABLE:   .000250 LBS/TON COAL    EFFICIENCY:  95.0%
                               .03  LBS/HR

        DUST COLLECTED PER DAY:          .3 TONS(DRY)

        TEMP OUT OF PROCESS:          120. F
        EXHAUST TEMPERATURE:          120. F

        SCFM FLOW:          0.    AT   70. F
        ACFM FLOW:          0.    AT  120. F

        L/G RATIO:                       .0
        PROCESS WATER FLOW:            0. GPM
        COOLING WATER FLOW:            0. GPM
        SUSPENDED SOLIDS OUT:          0. MG/L      %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                          UNITS    OPTION
     PPSES:  505.   TOPSIDE                                COKE       3

     CONTROL SYSTEM CONFIGURATION:

          TOPSIDE MAINTENANCE - LEVEL 2

     FEET OF ADDITIONAL DUCT:                0.    DIAMETER:  0.
     TOTAL PRESSURE DROP:                    0. INCHES
     0 FANS @    0. HP EACH       SPARE FAN CAPACITY:    0.%
     OPERATING HOURS AT FULL HP:     8760.
     OPERATING HOURS AT REDUCED HP:     0.
     STACK HEIGHT:                           0.    DIAMETER:  0.
     NO. OF OVENS                          60.
     OVEN HEIGHT                            6.0 METERS
     OVEN VOLUME                         1348.  CUBIC FEET
     TONS COKE/PUSH                        24.
     AVG. COKING TIME,HRS.                 17.5
     NO. CYCLES/DAY                        82.
     BULK DENSITY                          50.  LBS/CUBIC FT.
     YIELD                                   .70
     TONS COAL/YEAR                   1011967.
```

```
OPERATING COST:
                                                         UNITS    OPTION
     PPSES:  505.   TOPSIDE                              COKE       3

     CAPACITY:            .708 MILLION TONS/YEAR

     CATEGORY             QUANTITY          RATE                   ANNUAL COST ($)

                                *** UTILITIES ***

     WATER                     0. MGAL/YR   $  .1595/1000 GAL           0.
     ELECTRICITY               0. KWH/YR    $  .0266/KWH                0.
     STEAM                     0. MLBS/YR   $ 4.0920/MLBS               0.
     FUEL                      0. GAL/YR    $  .4180/GAL                0.


                             *** OPERATING LABOR ***

     DIRECT               8760. HRS/YR      $14.34/HR               125700. (A)
     SUPERVISION          1752. HRS/YR      $17.20/HR                30100. (B)


                          *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR         5900. HRS/YR      $14.34/HR                84600. (C)
     SUPERVISION          1180. HRS/YR      $17.20/HR                20300. (D)
     MATERIALS                                                       21200. (E)
     SUPPLIES                                                        18900. (F)
     WATER TREATMENT                                                     0.
     SOLID WASTE
       DISPOSAL                0. TON/YR    $ 8.25/TON                   0.

         DIRECT OPERATING COST                                      300800.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                          52100.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                       150400.
         TOTAL OPERATING COST                                       503300.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                 .71
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED        5235.24
         OPERATING COST AS PERCENT OF CAPITAL COST                       .0
         INSTALLATION TIME IN WEEKS                                      8.
         ESTIMATED LIFE OF SYSTEM IN YEARS                              99.
         KWH PER TON    CAPACITY                                         .0
         CAPITAL RECOVERY (10.00% OF TOTAL CAPITAL)                      0.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                0.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                  0.
         TOTAL ANNUALIZED COST - RETROFIT                           503300.
                               - NEW                                503300.
```

```
GENERAL INFORMATION:
                                                       UNITS    OPTION
     PPSES:  505.   TOPSIDE                             COKE       4

     CAPACITY:              .708 MILLION TONS/YEAR

     PARTICULATE
           LOAD IN:     .200000 LBS/TON COAL
           ALLOWABLE:   .006000 LBS/TON COAL   EFFICIENCY:  97.0%
                            .69  LBS/HR

     BSO
           LOAD IN:     .250000 LBS/TON COAL
           ALLOWABLE:   .007500 LBS/TON COAL   EFFICIENCY:  97.0%
                            .87  LBS/HR

     BAP
           LOAD IN:     .001000 LBS/TON COAL
           ALLOWABLE:   .000030 LBS/TON COAL   EFFICIENCY:  97.0%
                            .00  LBS/HR

     BENZENE
           LOAD IN:     .005000 LBS/TON COAL
           ALLOWABLE:   .000150 LBS/TON COAL   EFFICIENCY:  97.0%
                            .02  LBS/HR

     DUST COLLECTED PER DAY:          .3 TONS(DRY)

     TEMP OUT OF PROCESS:          120. F
     EXHAUST TEMPERATURE:          120. F

     SCFM FLOW:          0.    AT     70. F
     ACFM FLOW:          0.    AT    120. F

     L/G RATIO:                       .0
     PROCESS WATER FLOW:             0. GPM
     COOLING WATER FLOW:             0. GPM
     SUSPENDED SOLIDS OUT:           0. MG/L      %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                    UNITS   OPTION
   PPSES:  505.   TOPSIDE                            COKE      4

   CONTROL SYSTEM CONFIGURATION:

        TOPSIDE MAINTENANCE - LEVEL 1
        NEW LIDS AND CASTINGS

   FEET OF ADDITIONAL DUCT:             0.    DIAMETER:  0.
   TOTAL PRESSURE DROP:                 0. INCHES
   0 FANS @    0. HP EACH       SPARE FAN CAPACITY:   0.%
   OPERATING HOURS AT FULL HP:     8760.
   OPERATING HOURS AT REDUCED HP:       0.
   STACK HEIGHT:                        0.    DIAMETER:  0.
   NO. OF OVENS                        60.
   OVEN HEIGHT                          6.0 METERS
   OVEN VOLUME                       1348.  CUBIC FEET
   TONS COKE/PUSH                      24.
   AVG. COKING TIME,HRS.               17.5
   NO. CYCLES/DAY                      82.
   BULK DENSITY                        50.  LBS/CUBIC FT.
   YIELD                                .70
   TONS COAL/YEAR                 1011967.
```

```
CAPITAL COST:
                                                  UNITS    OPTION
     PPSES:  505.   TOPSIDE                       COKE       4

     CAPACITY:           .708 MILLION TONS/YEAR

     TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.)

          CATEGORY                               COST IN DOLLARS

                   *** DIRECT  COST ***
          EQUIPMENT OR MATERIAL                 55200.
          INSTRUMENTATION                           0.
          PIPING                                    0.
          ELECTRICAL                                0.
          FOUNDATIONS                               0.
          STRUCTURAL                                0.
          SITE WORK                                 0.
          INSULATION                                0.
          PROTECTIVE COATING                        0.
          BUILDINGS                                 0.
          EQUIPMENT/MATERIAL LABOR                  0.
               DIRECT COST SUBTOTAL                          55200.

                  *** INDIRECT  COST ***
          FIELD OVERHEAD                            0.
          CONTRACTORS FEE                        4300.
          ENGINEERING                            2000.
          FREIGHT                                3800.
          OFFSITE WORK                              0.
          TAXES                                   900.
          SHAKEDOWN                                 0.
          SPARES                                 1800.
          CONTINGENCY                           12200.
               INDIRECT COST SUBTOTAL                        25000.

               INTEREST DURING INSTALLATION                    900.

               TOTAL COST                                    81100.

               TOTAL COST WITH RETROFIT                     105400.
```

```
OPERATING COST:

                                                    UNITS    OPTION
      PPSES:  505.    TOPSIDE                        COKE       4

      CAPACITY:            .708 MILLION TONS/YEAR

      CATEGORY             QUANTITY         RATE                  ANNUAL COST ($)

                                *** UTILITIES ***

      WATER                  0. MGAL/YR     $  .1595/1000 GAL             0.
      ELECTRICITY            0. KWH/YR      $  .0266/KWH                  0.
      STEAM                  0. MLBS/YR     $ 4.0920/MLBS                 0.
      FUEL                   0. GAL/YR      $  .4180/GAL                  0.

                            *** OPERATING LABOR ***

      DIRECT              8760. HRS/YR      $14.34/HR                125700. (A)
      SUPERVISION         1752. HRS/YR      $17.20/HR                 30100. (B)

                          *** MAINTENANCE & SUPPLIES ***

      DIRECT LABOR         600. HRS/YR      $14.34/HR                  8600. (C)
      SUPERVISION          120. HRS/YR      $17.20/HR                  2100. (D)
      MATERIALS                                                        2200. (E)
      SUPPLIES                                                         1900. (F)
      WATER TREATMENT                                                     0.
      SOLID WASTE
        DISPOSAL             0. TON/YR      $ 8.25/TON                    0.

         DIRECT OPERATING COST                                       170600.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                           33300.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                         85300.
         TOTAL OPERATING COST                                        289200.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                  .41
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED         2946.19
         OPERATING COST AS PERCENT OF CAPITAL COST                     274.4
         INSTALLATION TIME IN WEEKS                                      12.
         ESTIMATED LIFE OF SYSTEM IN YEARS                               35.
         KWH PER TON    CAPACITY                                          .0
         CAPITAL RECOVERY (10.37% OF TOTAL CAPITAL)                   10900.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)              2100.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                2100.
         TOTAL ANNUALIZED COST - RETROFIT                            304300.
                               - NEW                                 300800.
```

```
GENERAL INFORMATION:
                                                    UNITS    OPTION
     PPSES:  506.   COMBUSTION STACK - OLD          COKE       2

     CAPACITY:             .708 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:   1.300000 LBS/TON COAL
          ALLOWABLE:  .260000 LBS/TON COAL   EFFICIENCY:  80.0%
                        30.04  LBS/HR

     BSO
          LOAD IN:    .006000 LBS/TON COAL
          ALLOWABLE:  .001200 LBS/TON COAL   EFFICIENCY:  80.0%
                          .14  LBS/HR

     BAP
          LOAD IN:    .000060 LBS/TON COAL
          ALLOWABLE:  .000012 LBS/TON COAL   EFFICIENCY:  80.0%
                          .00  LBS/HR

     DUST COLLECTED PER DAY:       1.4 TONS(DRY)

     TEMP OUT OF PROCESS:        450. F
     EXHAUST TEMPERATURE:        450. F

     SCFM FLOW:   67000.   AT    70. F
     ACFM FLOW:  115000.   AT   450. F

     L/G RATIO:                      .0
     PROCESS WATER FLOW:            0. GPM
     COOLING WATER FLOW:            0. GPM
     SUSPENDED SOLIDS OUT:          0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                 UNITS   OPTION
    PPSES:  506.   COMBUSTION STACK - OLD         COKE      2

    CONTROL SYSTEM CONFIGURATION:

         HEATING CONTROL AND PATCHING

    FEET OF ADDITIONAL DUCT:            0.    DIAMETER:  6.
    TOTAL PRESSURE DROP:                0. INCHES
    0 FANS @    0. HP EACH       SPARE FAN CAPACITY:   0.%
    OPERATING HOURS AT FULL HP:     8760.
    OPERATING HOURS AT REDUCED HP:      0.
    STACK HEIGHT:                       0.    DIAMETER:  0.
    NO. OF OVENS                       60.
    OVEN HEIGHT                         6.0 METERS
    OVEN VOLUME                      1348.  CUBIC FEET
    TONS COKE/PUSH                     24.
    AVG. COKING TIME,HRS.              17.5
    NO. CYCLES/DAY                     82.
    BULK DENSITY                       50.  LBS/CUBIC FT.
    YIELD                                .70
    TONS COAL/YEAR                1011967.
```

```
OPERATING COST:
                                                       UNITS    OPTION
    PPSES:  506.   COMBUSTION STACK - OLD               COKE       2

    CAPACITY:           .708 MILLION TONS/YEAR

    CATEGORY            QUANTITY          RATE                ANNUAL COST ($)

                              *** UTILITIES ***

    WATER                      0. MGAL/YR    $  .1595/1000 GAL            0.
    ELECTRICITY                0. KWH/YR     $  .0266/KWH                 0.
    STEAM                      0. MLBS/YR    $ 4.0920/MLBS                0.
    FUEL                       0. GAL/YR     $  .4180/GAL                 0.

                           *** OPERATING LABOR ***

    DIRECT              8760. HRS/YR     $14.34/HR               125700. (A)
    SUPERVISION         1752. HRS/YR     $17.20/HR                30100. (B)

                        *** MAINTENANCE & SUPPLIES ***

    DIRECT LABOR        5900. HRS/YR     $14.34/HR                84600. (C)
    SUPERVISION         1180. HRS/YR     $17.20/HR                20300. (D)
    MATERIALS                                                     21200. (E)
    SUPPLIES                                                      18900. (F)
    WATER TREATMENT                                                   0.
    SOLID WASTE
      DISPOSAL                 0. TON/YR     $ 8.25/TON               0.

        DIRECT OPERATING COST                                    300800.

        PAYROLL OVERHEAD =20.0% OF A+B+C+D                        52100.
        PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                     150400.
        TOTAL OPERATING COST                                     503300.
        OPERATING COST IN DOLLARS PER TON   PRODUCTION                .71
        OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED        956.44
        OPERATING COST AS PERCENT OF CAPITAL COST                      .0
        INSTALLATION TIME IN WEEKS                                     8.
        ESTIMATED LIFE OF SYSTEM IN YEARS                             99.
        KWH PER TON    CAPACITY                                        .0
        CAPITAL RECOVERY (10.00% OF TOTAL CAPITAL)                     0.
        ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)               0.
        PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                 0.
        TOTAL ANNUALIZED COST - RETROFIT                          503300.
                              - NEW                               503300.
```

Reproduced from best available copy.

```
GENERAL INFORMATION:
                                                  UNITS    OPTION
    PPSES:  506.   COMBUSTION STACK - OLD          COKE       3

    CAPACITY:           .708 MILLION TONS/YEAR

    PARTICULATE
         LOAD IN:    1.300000 LBS/TON COAL
         ALLOWABLE:   .130000 LBS/TON COAL   EFFICIENCY:  90.0%
                      15.02  LBS/HR

    BSO
         LOAD IN:     .006000 LBS/TON COAL
         ALLOWABLE:   .003000 LBS/TON COAL   EFFICIENCY:  50.0%
                        .35  LBS/HR

    BAP
         LOAD IN:     .000060 LBS/TON COAL
         ALLOWABLE:   .000030 LBS/TON COAL   EFFICIENCY:  50.0%
                        .00  LBS/HR

    DUST COLLECTED PER DAY:       1.6 TONS(DRY)

    TEMP OUT OF PROCESS:         450. F
    EXHAUST TEMPERATURE:         450. F

    SCFM FLOW:  107000.   AT     70. F
    ACFM FLOW:  184000.   AT    450. F

    L/G RATIO:                      .0
    PROCESS WATER FLOW:            0. GPM
    COOLING WATER FLOW:            0. GPM
    SUSPENDED SOLIDS OUT:          0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                   UNITS    OPTION
    PPSES:  506.   COMBUSTION STACK - OLD         COKE        3


    CONTROL SYSTEM CONFIGURATION:

           ESP
           FAN AND DRIVE
           DUCTWORK
           DUST HANDLING HOPPER & CONVEYORS
           DAMPERS
           FAN AND DRIVE ELECTRICAL


    SCA: 232.         TOTAL PLATE AREA:   51000. SQ.FT. @ 20% SPARE CAPACITY
    FEET OF ADDITIONAL DUCT:            250.    DIAMETER:  8.
    TOTAL PRESSURE DROP:                  6. INCHES
    2 FANS @  290. HP EACH        SPARE FAN CAPACITY: 100.%
    OPERATING HOURS AT FULL HP:     8760.
    OPERATING HOURS AT REDUCED HP:     0.
    STACK HEIGHT:                         0.     DIAMETER:  0.
    NO. OF OVENS                         60.
    OVEN HEIGHT                           6.0 METERS
    OVEN VOLUME                        1348.  CUBIC FEET
    TONS COKE/PUSH                       24.
    AVG. COKING TIME,HRS.                17.5
    NO. CYCLES/DAY                       82.
    BULK DENSITY                         50.  LBS/CUBIC FT.
    YIELD                                  .70
    TONS COAL/YEAR                  1011967.
```

```
CAPITAL COST:

     PPSES:  506.   COMBUSTION STACK - OLD        UNITS    OPTION
                                                   COKE        3

     CAPACITY:              .706 MILLION TONS/YEAR

     TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4078 COST.

          CATEGORY                                  COST IN DOLLARS

                    *** DIRECT  COST ***
          EQUIPMENT OR MATERIAL                 922400.
          INSTRUMENTATION                           0.
          PIPING                                    0.
          ELECTRICAL                             57200.
          FOUNDATIONS                             9000.
          STRUCTURAL                             56700.
          SITE WORK                               6100.
          INSULATION                             45800.
          PROTECTIVE COATING                      7000.
          BUILDINGS                               6700.
          EQUIPMENT/MATERIAL LABOR              432600.
               DIRECT COST SUBTOTAL                        1543500.

                   *** INDIRECT  COST ***
          FIELD OVERHEAD                        242800.
          CONTRACTORS FEE                       158900.
          ENGINEERING                           141700.
          FREIGHT                                73200.
          OFFSITE WORK                           36000.
          TAXES                                  55600.
          SHAKEDOWN                              69300.
          SPARES                                 66800.
          CONTINGENCY                           505600.
               INDIRECT COST SUBTOTAL                      1349900.

               INTEREST DURING INSTALLATION                 242600.

               TOTAL COST                                  3136000.

               TOTAL COST WITH RETROFIT                    3794500.
```

```
OPERATING COST:
                                                         UNITS    OPTION
    PPSES:  506.   COMBUSTION STACK - OLD                 COKE       3

    CAPACITY:             .708 MILLION TONS/YEAR

    CATEGORY                 QUANTITY           RATE                   ANNUAL COST ($)

                                    *** UTILITIES ***

    WATER                      0. MGAL/YR     $  .1595/1000 GAL             0.
    ELECTRICITY          2408996. KWH/YR      $  .0266/KWH              64100.
    STEAM                      0. MLBS/YR     $ 4.0920/MLBS                 0.
    FUEL                       0. GAL/YR      $  .4180/GAL                  0.

                                 *** OPERATING LABOR ***

    DIRECT                  8760. HRS/YR      $14.34/HR                125700. (A)
    SUPERVISION             1752. HRS/YR      $17.20/HR                 30100. (B)

                              *** MAINTENANCE & SUPPLIES ***

    DIRECT LABOR            7043. HRS/YR      $14.34/HR                101000. (C)
    SUPERVISION             1409. HRS/YR      $17.20/HR                 24200. (D)
    MATERIALS                                                           59100. (E)
    SUPPLIES                                                            27700. (F)
    WATER TREATMENT                                                         0.
    SOLID WASTE
      DISPOSAL               592. TON/YR      $ 8.25/TON                 4900.

         DIRECT OPERATING COST                                         436800.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                             56200.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                          183900.
         TOTAL OPERATING COST                                          676900.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                     .96
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED            1143.41
         OPERATING COST AS PERCENT OF CAPITAL COST                         17.8
         INSTALLATION TIME IN WEEKS                                       104.
         ESTIMATED LIFE OF SYSTEM IN YEARS                                 20.
         KWH PER TON    CAPACITY                                            3.4
         CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                   445700.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)              75900.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                75900.
         TOTAL ANNUALIZED COST - RETROFIT                            1274400.
                               - NEW                                 1170700.
```

```
GENERAL INFORMATION:
                                                     UNITS    OPTION
    PPSES:  506.   COMBUSTION STACK - OLD             COKE       4

    CAPACITY:              .708 MILLION TONS/YEAR

    PARTICULATE
          LOAD IN:    1.500000 LBS/TON COAL
          ALLOWABLE:   .026000 LBS/TON COAL    EFFICIENCY:  98.0%
                          3.00  LBS/HR

    BSO
          LOAD IN:     .006000 LBS/TON COAL
          ALLOWABLE:   .002400 LBS/TON COAL    EFFICIENCY:  60.0%
                           .28  LBS/HR

    BAP
          LOAD IN:     .000060 LBS/TON COAL
          ALLOWABLE:   .000024 LBS/TON COAL    EFFICIENCY:  60.0%
                           .00  LBS/HR

    DUST COLLECTED PER DAY:        1.8 TONS(DRY)

    TEMP OUT OF PROCESS:         450. F
    EXHAUST TEMPERATURE:         450. F

    SCFM FLOW:  107000.    AT    70. F
    ACFM FLOW:  184000.    AT   450. F

    L/G RATIO:                      .0
    PROCESS WATER FLOW:            0. GPM
    COOLING WATER FLOW:            0. GPM
    SUSPENDED SOLIDS OUT:          0. MG/L      %SOLIDS:      .0
```

```
GENERAL INFORMATION:
                                                   UNITS    OPTION
     PPSES:  506.   COMBUSTION STACK - OLD         COKE       4

     CONTROL SYSTEM CONFIGURATION:

            ESP
            FAN AND DRIVE
            DUCTWORK
            DUST HANDLING HOPPER & CONVEYORS
            DAMPERS
            FAN AND DRIVE ELECTRICAL

     SCA: 450.        TOTAL PLATE AREA:   99000. SQ.FT. @ 20% SPARE CAPACITY
     FEET OF ADDITIONAL DUCT:          250.    DIAMETER:  6.
     TOTAL PRESSURE DROP:                6. INCHES
     2 FANS @  290. HP EACH       SPARE FAN CAPACITY: 100.%
     OPERATING HOURS AT FULL HP:     8760.
     OPERATING HOURS AT REDUCED HP:     0.
     STACK HEIGHT:                      0.    DIAMETER:  0.
     NO. OF OVENS                      60.
     OVEN HEIGHT                        6.0 METERS
     OVEN VOLUME                     1346.  CUBIC FEET
     TONS COKE/PUSH                    24.
     AVG. COKING TIME,HRS.             17.5
     NO. CYCLES/DAY                    82.
     BULK DENSITY                      50.  LBS/CUBIC FT.
     YIELD                               .70
     TONS COAL/YEAR               1011967.
```

Reproduced from best available copy.

```
CAPITAL COST:

                                                  UNITS    OPTION
     PPSES:  506.   COMBUSTION STACK - OLD        COKE       4

     CAPACITY:           .708 MILLION TONS/YEAR

     TOTAL COST      (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COS

          CATEGORY                                COST IN DOLLARS

                    *** DIRECT  COST ***
          EQUIPMENT OR MATERIAL                1232700.
          INSTRUMENTATION                            0.
          PIPING                                     0.
          ELECTRICAL                             78700.
          FOUNDATIONS                            10500.
          STRUCTURAL                             77500.
          SITE WORK                               8800.
          INSULATION                             66600.
          PROTECTIVE COATING                      9300.
          BUILDINGS                               9800.
          EQUIPMENT/MATERIAL LABOR              570700.
               DIRECT COST SUBTOTAL                         2064600.

                   *** INDIRECT  COST ***
          FIELD OVERHEAD                        328700.
          CONTRACTORS FEE                       219300.
          ENGINEERING                           193100.
          FREIGHT                                89700.
          OFFSITE WORK                           51700.
          TAXES                                  72600.
          SHAKEDOWN                              95500.
          SPARES                                 93000.
          CONTINGENCY                           669700.
               INDIRECT COST SUBTOTAL                       1813300.

               INTEREST DURING INSTALLATION                  340900.

               TOTAL COST                                   4218800.

               TOTAL COST WITH RETROFIT                     5093900.
```

```
OPERATING COST:
                                                      UNITS    OPTION
     PPSES:  506.   COMBUSTION STACK - OLD            COKE       4

     CAPACITY:               .708 MILLION TONS/YEAR

     CATEGORY                QUANTITY          RATE                  ANNUAL COST ($)

                                  *** UTILITIES ***

     WATER                       0. MGAL/YR     $  .1595/1000 GAL          0.
     ELECTRICITY          3464055. KWH/YR       $  .0266/KWH           92200.
     STEAM                       0. MLBS/YR     $ 4.0920/MLBS              0.
     FUEL                        0. GAL/YR      $  .4180/GAL               0.

                               *** OPERATING LABOR ***

     DIRECT                  8760. HRS/YR      $14.34/HR              125700. (A)
     SUPERVISION             1752. HRS/YR      $17.20/HR               30100. (B)

                           *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR            7043. HRS/YR      $14.34/HR              101000. (C)
     SUPERVISION             1409. HRS/YR      $17.20/HR               24200. (D)
     MATERIALS                                                         59100. (E)
     SUPPLIES                                                          27700. (F)
     WATER TREATMENT                                                       0.
     SOLID WASTE
       DISPOSAL               645. TON/YR      $ 8.25/TON               5300.

         DIRECT OPERATING COST                                        465300.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                            56200.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                         183900.
         TOTAL OPERATING COST                                         705400.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                  1.00
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED          1094.28
         OPERATING COST AS PERCENT OF CAPITAL COST                       13.8
         INSTALLATION TIME IN WEEKS                                      104.
         ESTIMATED LIFE OF SYSTEM IN YEARS                                20.
         KWH PER TON    CAPACITY                                          4.9
         CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                  598300.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)            101900.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)              101900.
         TOTAL ANNUALIZED COST - RETROFIT                           1507500.
                               - NEW                                1369700.
```

```
GENERAL INFORMATION:
                                                 UNITS    OPTION
     PPSES:  506.   COMBUSTION STACK - OLD        COKE       5

     CAPACITY:             .708 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:    1.300000 LBS/TON COAL
          ALLOWABLE:   .026000 LBS/TON COAL   EFFICIENCY:  98.0%
                          3.00  LBS/HR

     BSO
          LOAD IN:     .006000 LBS/TON COAL
          ALLOWABLE:   .003000 LBS/TON COAL   EFFICIENCY:  50.0%
                           .35  LBS/HR

     BAP
          LOAD IN:     .000060 LBS/TON COAL
          ALLOWABLE:   .000030 LBS/TON COAL   EFFICIENCY:  50.0%
                           .00  LBS/HR

     DUST COLLECTED PER DAY:       1.8 TONS(DRY)

     TEMP OUT OF PROCESS:        450. F
     EXHAUST TEMPERATURE:        275. F

     SCFM FLOW:  198000.   AT    70. F
     ACFM FLOW:  275000.   AT   275. F

     L/G RATIO:                     .0
     PROCESS WATER FLOW:           0. GPM
     COOLING WATER FLOW:           0. GPM
     SUSPENDED SOLIDS OUT:         0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                      UNITS   OPTION
    PPSES:  506.   COMBUSTION STACK - OLD              COKE      5


    CONTROL SYSTEM CONFIGURATION:

            BAGHOUSE
            FAN AND DRIVE
            DUCTWORK
            DAMPERS
            FAN AND DRIVE ELECTRICAL


    A/C:   3.0       TOTAL CLOTH AREA:  110000. SQ.FT. @ 20% SPARE CAPACITY
    FEET OF ADDITIONAL DUCT:          250.     DIAMETER:  9.
    TOTAL PRESSURE DROP:               10. INCHES
    3 FANS @  346. HP EACH        SPARE FAN CAPACITY:  50.%
    OPERATING HOURS AT FULL HP:     6760.
    OPERATING HOURS AT REDUCED HP:     0.
    STACK HEIGHT:                      0.    DIAMETER:  0.
    NO. OF OVENS                      60.
    OVEN HEIGHT                        6.0 METERS
    OVEN VOLUME                     1348.  CUBIC FEET
    TONS COKE/PUSH                    24.
    AVG. COKING TIME,HRS.             17.5
    NO. CYCLES/DAY                    82.
    BULK DENSITY                      50.  LBS/CUBIC FT.
    YIELD                               .70
    TONS COAL/YEAR               1011967.
```

Reproduced from best available copy.

```
CAPITAL COST:
                                                  UNITS   OPTION
          PPSES:  506.  COMBUSTION STACK - OLD         COKE       5

          CAPACITY:          .708 MILLION TONS/YEAR

          TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4078 COST.

                CATEGORY                                COST IN DOLLARS

                          *** DIRECT  COST ***
                EQUIPMENT OR MATERIAL                  954500.
                INSTRUMENTATION                         15900.
                PIPING                                   1500.
                ELECTRICAL                              19900.
                FOUNDATIONS                             36900.
                STRUCTURAL                              11900.
                SITE WORK                                7200.
                INSULATION                                 0.
                PROTECTIVE COATING                      16800.
                BUILDINGS                               36000.
                EQUIPMENT/MATERIAL LABOR               330200.
                     DIRECT COST SUBTOTAL                          1458300.

                         *** INDIRECT  COST ***
                FIELD OVERHEAD                         174700.
                CONTRACTORS FEE                        127900.
                ENGINEERING                            118900.
                FREIGHT                                 46900.
                OFFSITE WORK                            27500.
                TAXES                                   54500.
                SHAKEDOWN                               58100.
                SPARES                                  53900.
                CONTINGENCY                            445800.
                     INDIRECT COST SUBTOTAL                        1108200.

                     INTEREST DURING INSTALLATION                   164100.

                     TOTAL COST                                    2730600.

                     TOTAL COST WITH RETROFIT                      3302700.
```

```
OPERATING COST:
                                                  UNITS    OPTION
    PPSES:  506.   COMBUSTION STACK - OLD          COKE       5

    CAPACITY:               .706 MILLION TONS/YEAR

    CATEGORY                QUANTITY          RATE                   ANNUAL COST ($)

                                    *** UTILITIES ***

    WATER                      0. MGAL/YR     $  .1595/1000 GAL           0.
    ELECTRICITY          3985249. KWH/YR      $  .0266/KWH           106100.
    STEAM                      0. MLBS/YR     $ 4.0920/MLBS               0.
    FUEL                       0. GAL/YR      $  .4160/GAL                0.

                                 *** OPERATING LABOR ***

    DIRECT                  2920. HRS/YR      $14.34/HR               41900. (A)
    SUPERVISION              564. HRS/YR      $17.20/HR               10000. (B)

                              *** MAINTENANCE & SUPPLIES ***

    DIRECT LABOR            6817. HRS/YR      $14.34/HR               97800. (C)
    SUPERVISION             1363. HRS/YR      $17.20/HR               23500. (D)
    MATERIALS                                                         58600. (E)
    SUPPLIES                                                          33300. (F)
    WATER TREATMENT                                                       0.
    SOLID WASTE
      DISPOSAL               645. TON/YR      $ 8.25/TON               5300.

        DIRECT OPERATING COST                                        376500.

        PAYROLL OVERHEAD =20.0% OF A+B+C+D                            34600.
        PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                         132600.
        TOTAL OPERATING COST                                         543700.
        OPERATING COST IN DOLLARS PER TON   PRODUCTION                   .77
        OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED           843.44
        OPERATING COST AS PERCENT OF CAPITAL COST                       16.5
        INSTALLATION TIME IN WEEKS                                      83.
        ESTIMATED LIFE OF SYSTEM IN YEARS                               20.
        KWH PER TON    CAPACITY                                          5.6
        CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                  387900.
        ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)             66100.
        PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)               66100.
        TOTAL ANNUALIZED COST - RETROFIT                            1063800.
                            - NEW                                   973600.
```

```
GENERAL INFORMATION:
                                                        UNITS    OPTION
     PPSES:  507.   COKE HANDLING                        COKE       2

     CAPACITY:            2.834 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:    1.000000 LBS/TON COAL
          ALLOWABLE:  .109000 LBS/TON COAL    EFFICIENCY:  89.1%
                       53.02  LBS/HR

     DUST COLLECTED PER DAY:        4.9 TONS(DRY)

     TEMP OUT OF PROCESS:          70. F
     EXHAUST TEMPERATURE:          70. F

     SCFM FLOW:    90000.    AT    70. F
     ACFM FLOW:    90000.    AT    70. F

     L/G RATIO:                     .0
     PROCESS WATER FLOW:            0. GPM
     COOLING WATER FLOW:            0. GPM
     SUSPENDED SOLIDS OUT:          0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                        UNITS   OPTION
    PPSES:  507.   COKE HANDLING                         COKE      2


    CONTROL SYSTEM CONFIGURATION:

         BAGHOUSE
         FAN AND DRIVE
         DUCTWORK
         CANOPY HOOD
         CONVEYOR TRANS PT. HOOD
         DAMPERS
         FAN AND DRIVE ELECTRICAL

    A/C:   6.0       TOTAL CLOTH AREA:   18000. SQ.FT. @ 20% SPARE CAPACITY
    FEET OF ADDITIONAL DUCT:          200.    DIAMETER:  5.
    TOTAL PRESSURE DROP:                8. INCHES
    2 FANS @  189. HP EACH       SPARE FAN CAPACITY: 100.%
    OPERATING HOURS AT FULL HP:     8322.
    OPERATING HOURS AT REDUCED HP:     0.
    STACK HEIGHT:                      0.    DIAMETER:  0.
    NO. OF OVENS                      60.
    HOOD SIZE:                       196. SQ.FT.
    OVEN HEIGHT                        6.0 METERS
    OVEN VOLUME                     1348.  CUBIC FEET
    TONS COKE/PUSH                    24.
    AVG. COKING TIME,HRS.             17.5
    NO. CYCLES/DAY                    82.
    BULK DENSITY                      50.  LBS/CUBIC FT.
    YIELD                               .70
    TONS COAL/YEAR               4047868.
```

```
CAPITAL COST:
                                                        UNITS   OPTION
        PPSES:  507.   COKE HANDLING                     COKE       2

        CAPACITY:          2.834 MILLION TONS/YEAR

        TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.)

             CATEGORY                              COST IN DOLLARS

                      *** DIRECT  COST ***
             EQUIPMENT OR MATERIAL                 396800.
             INSTRUMENTATION                         4000.
             PIPING                                   400.
             ELECTRICAL                             12600.
             FOUNDATIONS                            12300.
             STRUCTURAL                             46900.
             SITE WORK                               1800.
             INSULATION                                 0.
             PROTECTIVE COATING                     18800.
             BUILDINGS                               9000.
             EQUIPMENT/MATERIAL LABOR               99900.
                  DIRECT COST SUBTOTAL                          607000.

                     *** INDIRECT  COST ***
             FIELD OVERHEAD                         71500.
             CONTRACTORS FEE                        51800.
             ENGINEERING                            63800.
             FREIGHT                                20100.
             OFFSITE WORK                            7600.
             TAXES                                  24200.
             SHAKEDOWN                              22700.
             SPARES                                 20300.
             CONTINGENCY                           219100.
                  INDIRECT COST SUBTOTAL                        501100.

                  INTEREST DURING INSTALLATION                   60000.

                  TOTAL COST                                   1168100.

                  TOTAL COST WITH RETROFIT                     1299200.
```

```
OPERATING COST:
                                                    UNITS    OPTION
    PPSES:  507.   COKE HANDLING                     COKE       2

    CAPACITY:          2.834 MILLION TONS/YEAR

    CATEGORY                QUANTITY          RATE                   ANNUAL COST ($)

                                    *** UTILITIES ***

    WATER                          0. MGAL/YR    $  .1595/1000 GAL            0.
    ELECTRICITY              1375802. KWH/YR     $  .0266/KWH             36600.
    STEAM                          0. MLBS/YR    $ 4.0920/MLBS                0.
    FUEL                           0. GAL/YR     $  .4180/GAL                 0.


                                 *** OPERATING LABOR ***

    DIRECT                      2920. HRS/YR     $14.34/HR                41900. (A)
    SUPERVISION                  584. HRS/YR     $17.20/HR                10000. (B)


                              *** MAINTENANCE & SUPPLIES ***

    DIRECT LABOR                4100. HRS/YR     $14.34/HR                58800. (C)
    SUPERVISION                  820. HRS/YR     $17.20/HR                14100. (D)
    MATERIALS                                                             28700. (E)
    SUPPLIES                                                              16300. (F)
    WATER TREATMENT                                                           0.
    SOLID WASTE
      DISPOSAL                  1803. TON/YR     $ 8.25/TON               14900.

        DIRECT OPERATING COST                                            221300.

        PAYROLL OVERHEAD =20.0% OF A+B+C+D                                25000.
        PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                              84900.
        TOTAL OPERATING COST                                             331200.
        OPERATING COST IN DOLLARS PER TON   PRODUCTION                       .12
        OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED               183.66
        OPERATING COST AS PERCENT OF CAPITAL COST                           25.5
        INSTALLATION TIME IN WEEKS                                          83.
        ESTIMATED LIFE OF SYSTEM IN YEARS                                   20.
        KWH PER TON    CAPACITY                                              .5
        CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                       152600.
        ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                  26000.
        PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                    26000.
        TOTAL ANNUALIZED COST - RETROFIT                                 535800.
                              - NEW                                      515200.
```

```
GENERAL INFORMATION:
                                                       UNITS    OPTION
          PPSES:  508.   COAL PREHEATER                 COKE       2

          CAPACITY:             .992 MILLION TONS/YEAR

          PARTICULATE
                LOAD IN:    7.050000 LBS/TON COAL
                ALLOWABLE:   .352500 LBS/TON COAL   EFFICIENCY:  95.0%
                               60.01  LBS/HR

          BSO
                LOAD IN:    1.050000 LBS/TON COAL
                ALLOWABLE:   .420000 LBS/TON COAL   EFFICIENCY:  60.0%
                               71.50  LBS/HR

          BAP
                LOAD IN:     .000390 LBS/TON COAL
                ALLOWABLE:   .000156 LBS/TON COAL   EFFICIENCY:  60.0%
                                 .03  LBS/HR

          BENZENE
                LOAD IN:     .014000 LBS/TON COAL
                ALLOWABLE:   .007000 LBS/TON COAL   EFFICIENCY:  50.0%
                                1.19  LBS/HR

          DUST COLLECTED PER DAY:      13.0 TONS(DRY)

          TEMP OUT OF PROCESS:         180. F
          EXHAUST TEMPERATURE:         180. F

          SCFM FLOW:   17000.    AT     70. F
          ACFM FLOW:   20000.    AT    180. F

          L/G RATIO:                     6.5
          PROCESS WATER FLOW:          111. GPM
          COOLING WATER FLOW:            0. GPM
          SUSPENDED SOLIDS OUT:      15206. MG/L      %SOLIDS:   1.5
```

```
GENERAL INFORMATION:
                                                    UNITS   OPTION
     PPSES:  508.   COAL PREHEATER                   COKE      2


     CONTROL SYSTEM CONFIGURATION:

           VENTURI SCRUBBER
           MIST ELIMINATOR
           FAN AND DRIVE
           DUCTWORK
           WASTEWATER RECYCLE SYSTEM
           DAMPERS
           WASTE WATER RETURN SYSTEM
           WATER PUMPING SYSTEM
           FAN AND DRIVE ELECTRICAL


     FEET OF ADDITIONAL DUCT:          100.    DIAMETER:  3.
     TOTAL PRESSURE DROP:               18. INCHES
     2 FANS @   94. HP EACH        SPARE FAN CAPACITY: 100.%
     OPERATING HOURS AT FULL HP:      8322.
     OPERATING HOURS AT REDUCED HP:     0.
     STACK HEIGHT:                      0.    DIAMETER:  0.
     NO. OF OVENS                      60.
     OVEN HEIGHT                        6.0 METERS
     OVEN VOLUME                     1348.  CUBIC FEET
     TONS COKE/PUSH                    24.
     AVG. COKING TIME,HRS.             12.5
     NO. CYCLES/DAY                   115.
     BULK DENSITY                      50.  LBS/CUBIC FT.
     YIELD                               .70
     TONS COAL/YEAR               1416755.
```

```
CAPITAL COST:

     PPSES:  508.   COAL PREHEATER                  UNITS   OPTION
                                                     COKE      2

     CAPACITY:            .992 MILLION TONS/YEAR

     TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.)

          CATEGORY                               COST IN DOLLARS

                  *** DIRECT  COST ***
          EQUIPMENT OR MATERIAL             280800.
          INSTRUMENTATION                    51600.
          PIPING                             56700.
          ELECTRICAL                         84800.
          FOUNDATIONS                        18500.
          STRUCTURAL                         29100.
          SITE WORK                           3400.
          INSULATION                          6600.
          PROTECTIVE COATING                  7100.
          BUILDINGS                           9300.
          EQUIPMENT/MATERIAL LABOR          100300.
               DIRECT COST SUBTOTAL                        648200.

                 *** INDIRECT  COST ***
          FIELD OVERHEAD                     97500.
          CONTRACTORS FEE                    45400.
          ENGINEERING                       111800.
          FREIGHT                            18800.
          OFFSITE WORK                       17300.
          TAXES                              24600.
          SHAKEDOWN                          31400.
          SPARES                             29200.
          CONTINGENCY                       217900.
               INDIRECT COST SUBTOTAL                      593900.

               INTEREST DURING INSTALLATION                101000.

               TOTAL COST                                 1343100.

               TOTAL COST WITH RETROFIT                   1474200.
```

```
OPERATING COST:
                                                      UNITS   OPTION
     PPSES:  508.   COAL PREHEATER                    COKE      2

     CAPACITY:            .992 MILLION TONS/YEAR

     CATEGORY             QUANTITY          RATE                   ANNUAL COST ($)

                                  *** UTILITIES ***

     WATER               11035. MGAL/YR    $  .1595/1000 GAL          1800.
     ELECTRICITY        548080. KWH/YR     $  .0266/KWH              14600.
     STEAM                   0. MLBS/YR    $ 4.0920/MLBS                 0.
     FUEL                    0. GAL/YR     $  .4180/GAL                  0.


                               *** OPERATING LABOR ***

     DIRECT               8760. HRS/YR     $14.34/HR                125700. (A)
     SUPERVISION          1752. HRS/YR     $17.20/HR                 30100. (B)


                            *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR         8567. HRS/YR     $14.34/HR                122900. (C)
     SUPERVISION          1713. HRS/YR     $17.20/HR                 29500. (D)
     MATERIALS                                                      104800. (E)
     SUPPLIES                                                        40200. (F)
     WATER TREATMENT                                                     0.
     SOLID WASTE
       DISPOSAL           9489. TON/YR     $ 8.25/TON                78300.

         DIRECT OPERATING COST                                      547900.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                          61600.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                       226600.
         TOTAL OPERATING COST                                       836100.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                  .84
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED          176.23
         OPERATING COST AS PERCENT OF CAPITAL COST                      56.7
         INSTALLATION TIME IN WEEKS                                    104.
         ESTIMATED LIFE OF SYSTEM IN YEARS                              15.
         KWH PER TON    CAPACITY                                         .6
         CAPITAL RECOVERY (13.15% OF TOTAL CAPITAL)                193800.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)           29500.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)             29500.
         TOTAL ANNUALIZED COST - RETROFIT                          1088900.
                               - NEW                               1066500.
```

```
GENERAL INFORMATION:
                                                          UNITS    OPTION
     PPSES:  508.   COAL PREHEATER                        COKE       3

     CAPACITY:              .992 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:    7.050000 LBS/TON COAL
          ALLOWABLE:   .352500 LBS/TON COAL   EFFICIENCY:  95.0%
                        60.01  LBS/HR

     BSO
          LOAD IN:    1.050000 LBS/TON COAL
          ALLOWABLE:   .577500 LBS/TON COAL   EFFICIENCY:  45.0%
                        98.31  LBS/HR

     BAP
          LOAD IN:     .000390 LBS/TON COAL
          ALLOWABLE:   .000214 LBS/TON COAL   EFFICIENCY:  45.0%
                          .04  LBS/HR

     BENZENE
          LOAD IN:     .014000 LBS/TON COAL
          ALLOWABLE:   .007700 LBS/TON COAL   EFFICIENCY:  45.0%
                         1.31  LBS/HR

     DUST COLLECTED PER DAY:        13.0 TONS(DRY)

     TEMP OUT OF PROCESS:          180. F
     EXHAUST TEMPERATURE:          180. F

     SCFM FLOW:   17000.   AT       70. F
     ACFM FLOW:   20000.   AT      180. F

     L/G RATIO:                       .0
     PROCESS WATER FLOW:             0. GPM
     COOLING WATER FLOW:             0. GPM
     SUSPENDED SOLIDS OUT:           0. MG/L      %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                       UNITS   OPTION
    PPSES:  508.   COAL PREHEATER                       COKE       3


    CONTROL SYSTEM CONFIGURATION:

         ESP
         FAN AND DRIVE
         DUCTWORK
         DUST HANDLING HOPPER & CONVEYORS
         DAMPERS
         FAN AND DRIVE ELECTRICAL


    SCA: 324.         TOTAL PLATE AREA:    8000. SQ.FT. @ 20% SPARE CAPACITY
    FEET OF ADDITIONAL DUCT:         100.    DIAMETER:  3.
    TOTAL PRESSURE DROP:               4. INCHES
    2 FANS @   21. HP EACH        SPARE FAN CAPACITY: 100.%
    OPERATING HOURS AT FULL HP:     8322.
    OPERATING HOURS AT REDUCED HP:     0.
    STACK HEIGHT:                      0.    DIAMETER:  0.
    NO. OF OVENS                      60.
    OVEN HEIGHT                        6.0 METERS
    OVEN VOLUME                     1348.  CUBIC FEET
    TONS COKE/PUSH                    24.
    AVG. COKING TIME,HRS.             12.5
    NO. CYCLES/DAY                   115.
    BULK DENSITY                      50.  LBS/CUBIC FT.
    YIELD                               .70
    TONS COAL/YEAR               1416755.
```

```
CAPITAL COST:
                                                      UNITS   OPTION
        PPSES:  508.   COAL PREHEATER                  COKE      3

        CAPACITY:            .992 MILLION TONS/YEAR

        TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4078 COST.

              CATEGORY                              COST IN DOLLARS

                         *** DIRECT  COST ***
              EQUIPMENT OR MATERIAL               328700.
              INSTRUMENTATION                          0.
              PIPING                                   0.
              ELECTRICAL                           26600.
              FOUNDATIONS                           4400.
              STRUCTURAL                           37200.
              SITE WORK                             2100.
              INSULATION                           16000.
              PROTECTIVE COATING                    5000.
              BUILDINGS                             2400.
              EQUIPMENT/MATERIAL LABOR            143700.
                    DIRECT COST SUBTOTAL                        566100.

                        *** INDIRECT  COST ***
              FIELD OVERHEAD                       94300.
              CONTRACTORS FEE                      59200.
              ENGINEERING                          75000.
              FREIGHT                              18900.
              OFFSITE WORK                         12500.
              TAXES                                22100.
              SHAKEDOWN                            30300.
              SPARES                               29700.
              CONTINGENCY                         200900.
                    INDIRECT COST SUBTOTAL                      542900.

                    INTEREST DURING INSTALLATION                 89200.

                    TOTAL COST                                 1198200.

                    TOTAL COST WITH RETROFIT                   1311600.
```

```
OPERATING COST:
                                                          UNITS    OPTION
    PPSES:  508.   COAL PREHEATER                         COKE       3

    CAPACITY:            .992 MILLION TONS/YEAR

    CATEGORY             QUANTITY          RATE                   ANNUAL COST ($)

                                *** UTILITIES ***

    WATER                      0. MGAL/YR    $  .1595/1000 GAL            0.
    ELECTRICITY          363839. KWH/YR      $  .0266/KWH              9700.
    STEAM                      0. MLBS/YR    $ 4.0920/MLBS                0.
    FUEL                       0. GAL/YR     $  .4180/GAL                 0.

                             *** OPERATING LABOR ***

    DIRECT                 8760. HRS/YR      $14.34/HR               125700. (A)
    SUPERVISION            1752. HRS/YR      $17.20/HR                30100. (B)

                          *** MAINTENANCE & SUPPLIES ***

    DIRECT LABOR           2517. HRS/YR      $14.34/HR                36100. (C)
    SUPERVISION             503. HRS/YR      $17.20/HR                 8700. (D)
    MATERIALS                                                         19700. (E)
    SUPPLIES                                                           9700. (F)
    WATER TREATMENT                                                       0.
    SOLID WASTE
      DISPOSAL             4744. TON/YR      $ 8.25/TON               39100.

        DIRECT OPERATING COST                                        278800.

        PAYROLL OVERHEAD =20.0% OF A+B+C+D                            40100.
        PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                         115000.
        TOTAL OPERATING COST                                         433900.
        OPERATING COST IN DOLLARS PER TON   PRODUCTION                   .44
        OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED            91.46
        OPERATING COST AS PERCENT OF CAPITAL COST                       33.1
        INSTALLATION TIME IN WEEKS                                     104.
        ESTIMATED LIFE OF SYSTEM IN YEARS                               20.
        KWH PER TON    CAPACITY                                           .4
        CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                  154100.
        ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)             26200.
        PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)               26200.
        TOTAL ANNUALIZED COST - RETROFIT                            640400.
                              - NEW                                 622600.
```

```
GENERAL INFORMATION:
                                                          UNITS    OPTION
     PPSES:  508.   COAL PREHEATER                         COKE       4

     CAPACITY:              .992 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:    7.050000 LBS/TON COAL
          ALLOWABLE:   .141000 LBS/TON COAL   EFFICIENCY:  98.0%
                      24.00    LBS/HR

     BSO
          LOAD IN:    1.050000 LBS/TON COAL
          ALLOWABLE:   .420000 LBS/TON COAL   EFFICIENCY:  60.0%
                      71.50    LBS/HR

     BAP
          LOAD IN:     .000390 LBS/TON COAL
          ALLOWABLE:   .000156 LBS/TON COAL   EFFICIENCY:  60.0%
                         .03   LBS/HR

     BENZENE
          LOAD IN:     .014000 LBS/TON COAL
          ALLOWABLE:   .007000 LBS/TON COAL   EFFICIENCY:  50.0%
                       1.19    LBS/HR

     DUST COLLECTED PER DAY:       13.4 TONS(DRY)

     TEMP OUT OF PROCESS:          180. F
     EXHAUST TEMPERATURE:          180. F

     SCFM FLOW:   17000.    AT      70. F
     ACFM FLOW:   20000.    AT     180. F

     L/G RATIO:                     6.5
     PROCESS WATER FLOW:           111. GPM
     COOLING WATER FLOW:             0. GPM
     SUSPENDED SOLIDS OUT:       15206. MG/L      %SOLIDS:   1.5
```

```
GENERAL INFORMATION:
                                                  UNITS   OPTION
    PPSES:  508.   COAL PREHEATER                  COKE      4


    CONTROL SYSTEM CONFIGURATION:

         VENTURI SCRUBBER
         MIST ELIMINATOR
         FAN AND DRIVE
         DUCTWORK
         WASTEWATER RECYCLE SYSTEM
         DAMPERS
         WASTE WATER RETURN SYSTEM
         WATER PUMPING SYSTEM
         FAN AND DRIVE ELECTRICAL


    FEET OF ADDITIONAL DUCT:          100.    DIAMETER:  3.
    TOTAL PRESSURE DROP:               33. INCHES
    2 FANS @  173. HP EACH       SPARE FAN CAPACITY: 100.%
    OPERATING HOURS AT FULL HP:     8322.
    OPERATING HOURS AT REDUCED HP:     0.
    STACK HEIGHT:                      0.    DIAMETER:  0.
    NO. OF OVENS                      60.
    OVEN HEIGHT                        6.0 METERS
    OVEN VOLUME                     1348.  CUBIC FEET
    TONS COKE/PUSH                    24.
    AVG. COKING TIME,HRS.             12.5
    NO. CYCLES/DAY                   115.
    BULK DENSITY                      50.  LBS/CUBIC FT.
    YIELD                               .70
    TONS COAL/YEAR               1416755.
```

```
CAPITAL COST:
                                                       UNITS    OPTION
    PPSES:  508.   COAL PREHEATER                       COKE       4

    CAPACITY:             .992 MILLION TONS/YEAR

    TOTAL COST      (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.

          CATEGORY                                 COST IN DOLLARS

                    *** DIRECT  COST ***
          EQUIPMENT OR MATERIAL                   301700.
          INSTRUMENTATION                          51600.
          PIPING                                   56700.
          ELECTRICAL                               84800.
          FOUNDATIONS                              19500.
          STRUCTURAL                               29100.
          SITE WORK                                 3400.
          INSULATION                                6600.
          PROTECTIVE COATING                        7300.
          BUILDINGS                                 9300.
          EQUIPMENT/MATERIAL LABOR                100400.
               DIRECT COST SUBTOTAL                          670400.

                   *** INDIRECT  COST ***
          FIELD OVERHEAD                           97900.
          CONTRACTORS FEE                          47600.
          ENGINEERING                             113500.
          FREIGHT                                  18900.
          OFFSITE WORK                             17800.
          TAXES                                    26300.
          SHAKEDOWN                                33200.
          SPARES                                   30200.
          CONTINGENCY                             224800.
               INDIRECT COST SUBTOTAL                        610200.

               INTEREST DURING INSTALLATION                  104600.

               TOTAL COST                                   1385200.

               TOTAL COST WITH RETROFIT                     1520500.
```

```
OPERATING COST:

   PPSES:  508.   COAL PREHEATER                 UNITS   OPTION
                                                  COKE      4

   CAPACITY:            .992 MILLION TONS/YEAR

   CATEGORY             QUANTITY        RATE
                                                            ANNUAL COST ($)

                               *** UTILITIES ***

   WATER               11035. MGAL/YR    $  .1595/1000 GAL        1800.
   ELECTRICITY        998794. KWH/YR     $  .0266/KWH            26600.
   STEAM                   0. MLBS/YR    $ 4.0920/MLBS               0.
   FUEL                    0. GAL/YR     $  .4180/GAL                0.

                            *** OPERATING LABOR ***

   DIRECT               8760. HRS/YR     $14.34/HR              125700. (A)
   SUPERVISION          1752. HRS/YR     $17.20/HR               30100. (B)

                         *** MAINTENANCE & SUPPLIES ***

   DIRECT LABOR         8767. HRS/YR     $14.34/HR              125700. (C)
   SUPERVISION          1753. HRS/YR     $17.20/HR               30200. (D)
   MATERIALS                                                    107000. (E)
   SUPPLIES                                                      41000. (F)
   WATER TREATMENT                                                   0.
   SOLID WASTE
     DISPOSAL           9788. TON/YR     $ 8.25/TON              80800.

       DIRECT OPERATING COST                                    568900.

       PAYROLL OVERHEAD =20.0% OF A+B+C+D                        62300.
       PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                     229900.
       TOTAL OPERATING COST                                     861100.
       OPERATING COST IN DOLLARS PER TON   PRODUCTION               .87
       OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED       175.94
       OPERATING COST AS PERCENT OF CAPITAL COST                   56.6
       INSTALLATION TIME IN WEEKS                                 104.
       ESTIMATED LIFE OF SYSTEM IN YEARS                           15.
       KWH PER TON    CAPACITY                                      1.0
       CAPITAL RECOVERY (13.15% OF TOTAL CAPITAL)              199900.
       ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)         30400.
       PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)           30400.
       TOTAL ANNUALIZED COST - RETROFIT                       1121800.
                             - NEW                            1098600.
```

```
GENERAL INFORMATION:

    PPSES:  508.   COAL PREHEATER                    UNITS   OPTION
                                                      COKE      5
    CAPACITY:            .992 MILLION TONS/YEAR

    PARTICULATE
         LOAD IN:    7.050000 LBS/TON COAL
         ALLOWABLE:   .070500 LBS/TON COAL    EFFICIENCY:  99.0%
                        12.00  LBS/HR

    BSO
         LOAD IN:    1.050000 LBS/TON COAL
         ALLOWABLE:   .525000 LBS/TON COAL    EFFICIENCY:  50.0%
                        89.36  LBS/HR

    BAP
         LOAD IN:     .000390 LBS/TON COAL
         ALLOWABLE:   .000195 LBS/TON COAL    EFFICIENCY:  50.0%
                          .03  LBS/HR

    BENZENE
         LOAD IN:     .014000 LBS/TON COAL
         ALLOWABLE:   .007000 LBS/TON COAL    EFFICIENCY:  50.0%
                         1.19  LBS/HR

    DUST COLLECTED PER DAY:       13.5 TONS(DRY)

    TEMP OUT OF PROCESS:         180. F
    EXHAUST TEMPERATURE:         180. F

    SCFM FLOW:   17000.   AT      70. F
    ACFM FLOW:   20000.   AT     180. F

    L/G RATIO:                      .0
    PROCESS WATER FLOW:            0. GPM
    COOLING WATER FLOW:            0. GPM
    SUSPENDED SOLIDS OUT:          0. MG/L      %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                       UNITS   OPTION
     PPSES:  508.   COAL PREHEATER                      COKE      5

     CONTROL SYSTEM CONFIGURATION:

          ESP
          FAN AND DRIVE
          DUCTWORK
          DUST HANDLING HOPPER & CONVEYORS
          DAMPERS
          FAN AND DRIVE ELECTRICAL

     SCA: 538.      TOTAL PLATE AREA:   13000. SQ.FT. @ 20% SPARE CAPACITY
     FEET OF ADDITIONAL DUCT:            100.    DIAMETER:  3.
     TOTAL PRESSURE DROP:                  4. INCHES
     2 FANS @   21. HP EACH       SPARE FAN CAPACITY: 100.%
     OPERATING HOURS AT FULL HP:     8322.
     OPERATING HOURS AT REDUCED HP:     0.
     STACK HEIGHT:                      0.    DIAMETER:  0.
     NO. OF OVENS                      60.
     OVEN HEIGHT                        6.0 METERS
     OVEN VOLUME                     1348.  CUBIC FEET
     TONS COKE/PUSH                    24.
     AVG. COKING TIME,HRS.             12.5
     NO. CYCLES/DAY                   115.
     BULK DENSITY                      50.  LBS/CUBIC FT.
     YIELD                               .70
     TONS COAL/YEAR               1416755.
```

```
CAPITAL COST:
                                                        UNITS   OPTION
     PPSES:  508.   COAL PREHEATER                      COKE      5

     CAPACITY:            .992 MILLION TONS/YEAR

     TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.)

            CATEGORY                                COST IN DOLLARS

                       *** DIRECT  COST ***
            EQUIPMENT OR MATERIAL                397400.
            INSTRUMENTATION                           0.
            PIPING                                    0.
            ELECTRICAL                            31900.
            FOUNDATIONS                            4800.
            STRUCTURAL                            42400.
            SITE WORK                              2800.
            INSULATION                            21100.
            PROTECTIVE COATING                     5500.
            BUILDINGS                              3100.
            EQUIPMENT/MATERIAL LABOR             177500.
                 DIRECT COST SUBTOTAL                       686500.

                      *** INDIRECT  COST ***
            FIELD OVERHEAD                       115400.
            CONTRACTORS FEE                       74000.
            ENGINEERING                           87700.
            FREIGHT                               23000.
            OFFSITE WORK                          16300.
            TAXES                                 26200.
            SHAKEDOWN                             36700.
            SPARES                                36100.
            CONTINGENCY                          241300.
                 INDIRECT COST SUBTOTAL                     656700.

                 INTEREST DURING INSTALLATION               112500.

                 TOTAL COST                                1455700.

                 TOTAL COST WITH RETROFIT                  1594900.
```

```
OPERATING COST:
                                                   UNITS   OPTION
     PPSES:  508.   COAL PREHEATER                  COKE      5

     CAPACITY:          .992 MILLION TONS/YEAR

     CATEGORY                QUANTITY           RATE                  ANNUAL COST ($)

                                    *** UTILITIES ***

     WATER                        0. MGAL/YR     $  .1595/1000 GAL              0.
     ELECTRICITY            471304. KWH/YR      $  .0266/KWH               12500.
     STEAM                        0. MLBS/YR     $ 4.0920/MLBS                  0.
     FUEL                         0. GAL/YR      $  .4180/GAL                   0.

                                 *** OPERATING LABOR ***

     DIRECT                    8760. HRS/YR     $14.34/HR                 125700. (A)
     SUPERVISION               1752. HRS/YR     $17.20/HR                  30100. (B)

                              *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR              2517. HRS/YR     $14.34/HR                  36100. (C)
     SUPERVISION                503. HRS/YR     $17.20/HR                   8700. (D)
     MATERIALS                                                             19700. (E)
     SUPPLIES                                                               9700. (F)
     WATER TREATMENT                                                           0.
     SOLID WASTE
       DISPOSAL                4944. TON/YR     $ 8.25/TON                 40800.

         DIRECT OPERATING COST                                            283300.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                                40100.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                             115000.
         TOTAL OPERATING COST                                             438400.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                       .44
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED                88.67
         OPERATING COST AS PERCENT OF CAPITAL COST                          27.5
         INSTALLATION TIME IN WEEKS                                        104.
         ESTIMATED LIFE OF SYSTEM IN YEARS                                  20.
         KWH PER TON    CAPACITY                                             .5
         CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                       187300.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                  31900.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                    31900.
         TOTAL ANNUALIZED COST - RETROFIT                                 689500.
                               - NEW                                      667600.
```

```
GENERAL INFORMATION:
                                                          UNITS   OPTION
     PPSES:  509.   COAL PREPARATION                       COKE      2

     CAPACITY:           2.834 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:     .500000 LBS/TON COAL
          ALLOWABLE:   .015000 LBS/TON COAL   EFFICIENCY:  97.0%
                          7.30  LBS/HR

     DUST COLLECTED PER DAY:        2.7 TONS(DRY)

     TEMP OUT OF PROCESS:          70. F
     EXHAUST TEMPERATURE:          70. F

     SCFM FLOW:   70000.    AT     70. F
     ACFM FLOW:   70000.    AT     70. F

     L/G RATIO:                      .0
     PROCESS WATER FLOW:            0. GPM
     COOLING WATER FLOW:            0. GPM
     SUSPENDED SOLIDS OUT:          0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                    UNITS   OPTION
    PPSES:  509.   COAL PREPARATION                  COKE      2

    CONTROL SYSTEM CONFIGURATION:

         BAGHOUSE
         FAN AND DRIVE
         DUCTWORK
         CONVEYOR TRANS PT. HOOD
         DAMPERS
         FAN AND DRIVE ELECTRICAL

    A/C:   6.0       TOTAL CLOTH AREA:   14000. SQ.FT. @ 20% SPARE CAPACITY
    FEET OF ADDITIONAL DUCT:          300.    DIAMETER:  5.
    TOTAL PRESSURE DROP:                8. INCHES
    2 FANS @  147. HP EACH       SPARE FAN CAPACITY: 100.%
    OPERATING HOURS AT FULL HP:     8322.
    OPERATING HOURS AT REDUCED HP:     0.
    STACK HEIGHT:                      0.    DIAMETER:  0.
    NO. OF OVENS                      60.
    OVEN HEIGHT                        6.0 METERS
    OVEN VOLUME                     1348.  CUBIC FEET
    TONS COKE/PUSH                    24.
    AVG. COKING TIME,HRS.             17.5
    NO. CYCLES/DAY                    82.
    BULK DENSITY                      50.  LBS/CUBIC FT.
    YIELD                               .70
    TONS COAL/YEAR               4047868.
```

```
CAPITAL COST:
                                                          UNITS   OPTION
     PPSES:  509.   COAL PREPARATION              COKE       2

     CAPACITY:          2.834 MILLION TONS/YEAR

     TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.)

          CATEGORY                              COST IN DOLLARS

                   *** DIRECT  COST ***
          EQUIPMENT OR MATERIAL               252300.
          INSTRUMENTATION                       4000.
          PIPING                                 500.
          ELECTRICAL                            9100.
          FOUNDATIONS                           4500.
          STRUCTURAL                           24100.
          SITE WORK                              500.
          INSULATION                               0.
          PROTECTIVE COATING                   16100.
          BUILDINGS                                0.
          EQUIPMENT/MATERIAL LABOR             73600.
               DIRECT COST SUBTOTAL                        384700.

                  *** INDIRECT  COST ***
          FIELD OVERHEAD                       45900.
          CONTRACTORS FEE                      27300.
          ENGINEERING                          35100.
          FREIGHT                              23200.
          OFFSITE WORK                          1000.
          TAXES                                15300.
          SHAKEDOWN                             7400.
          SPARES                                7500.
          CONTINGENCY                         160000.
               INDIRECT COST SUBTOTAL                      322700.

               INTEREST DURING INSTALLATION                 26300.

               TOTAL COST                                  733700.

               TOTAL COST WITH RETROFIT                    814700.
```

```
OPERATING COST:
                                                    UNITS    OPTION
     PPSES:  509.   COAL PREPARATION                 COKE       2

     CAPACITY:          2.834 MILLION TONS/YEAR

     CATEGORY                QUANTITY          RATE                  ANNUAL COST ($)

                                    *** UTILITIES ***

     WATER                       0. MGAL/YR     $  .1595/1000 GAL            0.
     ELECTRICITY           1016568. KWH/YR      $  .0266/KWH             27100.
     STEAM                       0. MLBS/YR     $ 4.0920/MLBS                0.
     FUEL                        0. GAL/YR      $  .4180/GAL                 0.


                                *** OPERATING LABOR ***

     DIRECT                    500. HRS/YR      $14.34/HR                 7200. (A)
     SUPERVISION               100. HRS/YR      $17.20/HR                 1700. (B)


                             *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR             3000. HRS/YR      $14.34/HR                43000. (C)
     SUPERVISION               600. HRS/YR      $17.20/HR                10300. (D)
     MATERIALS                                                           17600. (E)
     SUPPLIES                                                            11400. (F)
     WATER TREATMENT                                                         0.
     SOLID WASTE
       DISPOSAL                982. TON/YR      $ 8.25/TON                8100.

          DIRECT OPERATING COST                                         126400.

          PAYROLL OVERHEAD =20.0% OF A+B+C+D                             12400.
          PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                           45600.
          TOTAL OPERATING COST                                          184400.
          OPERATING COST IN DOLLARS PER TON   PRODUCTION                    .07
          OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED            187.86
          OPERATING COST AS PERCENT OF CAPITAL COST                        22.6
          INSTALLATION TIME IN WEEKS                                        52.
          ESTIMATED LIFE OF SYSTEM IN YEARS                                 20.
          KWH PER TON    CAPACITY                                            .4
          CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                     95700.
          ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)               16300.
          PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                 16300.
          TOTAL ANNUALIZED COST - RETROFIT                              312700.
                                - NEW                                   300000.
```

```
GENERAL INFORMATION:
                                                      UNITS    OPTION
     PPSES:  510.   COAL STORAGE YARD                 COKE       2

     CAPACITY:              2.834 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:     .150000 LBS/TON COAL
          ALLOWABLE:   .060000 LBS/TON COAL   EFFICIENCY:  60.0%
                        27.73  LBS/HR

     DUST COLLECTED PER DAY:          .5 TONS(DRY)

     TEMP OUT OF PROCESS:           70. F
     EXHAUST TEMPERATURE:           70. F

     SCFM FLOW:        0.    AT     70. F
     ACFM FLOW:        0.    AT     70. F

     L/G RATIO:                       .0
     PROCESS WATER FLOW:           170. GPM
     COOLING WATER FLOW:             0. GPM
     SUSPENDED SOLIDS OUT:           0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:

     PPSES:  510.   COAL STORAGE YARD             UNITS    OPTION
                                                   COKE       2

     CONTROL SYSTEM CONFIGURATION:

          TRANSFER POINT SPRAY
          SPRAY TRUCK
          WATER PUMPING SYSTEM

     FEET OF ADDITIONAL DUCT:              0.    DIAMETER:  0.
     TOTAL PRESSURE DROP:                  0. INCHES
     0 FANS @    0. HP EACH        SPARE FAN CAPACITY:    0.%
     OPERATING HOURS AT FULL HP:    8760.
     OPERATING HOURS AT REDUCED HP:        0.
     STACK HEIGHT:                         0.    DIAMETER:  0.
     NO. OF OVENS                         60.
     OVEN HEIGHT                           6.0 METERS
     OVEN VOLUME                        1348.  CUBIC FEET
     TONS COKE/PUSH                       24.
     AVG. COKING TIME,HRS.                17.5
     NO. CYCLES/DAY                       82.
     BULK DENSITY                         50.  LBS/CUBIC FT.
     YIELD                                  .70
     TONS COAL/YEAR                  4047868.
```

```
CAPITAL COST:
                                              UNITS   OPTION
    PPSES:  510.   COAL STORAGE YARD           COKE      2

    CAPACITY:          2.834 MILLION TONS/YEAR

    TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.)

         CATEGORY                         COST IN DOLLARS

                   *** DIRECT  COST ***
         EQUIPMENT OR MATERIAL              90100.
         INSTRUMENTATION                     3800.
         PIPING                             22900.
         ELECTRICAL                         15600.
         FOUNDATIONS                          100.
         STRUCTURAL                          4400.
         SITE WORK                            500.
         INSULATION                         19800.
         PROTECTIVE COATING                   200.
         BUILDINGS                              0.
         EQUIPMENT/MATERIAL LABOR            4000.
              DIRECT COST SUBTOTAL                    161400.

                  *** INDIRECT  COST ***
         FIELD OVERHEAD                     11600.
         CONTRACTORS FEE                     7800.
         ENGINEERING                        31600.
         FREIGHT                             1000.
         OFFSITE WORK                         200.
         TAXES                               6300.
         SHAKEDOWN                            600.
         SPARES                              1100.
         CONTINGENCY                        36700.
              INDIRECT COST SUBTOTAL                   96900.

              INTEREST DURING INSTALLATION              7100.

              TOTAL COST                              265400.

              TOTAL COST WITH RETROFIT                297200.
```

```
OPERATING COST:
                                                  UNITS   OPTION
     PPSES:  510.   COAL STORAGE YARD              COKE      2

     CAPACITY:         2.834 MILLION TONS/YEAR

     CATEGORY                   QUANTITY         RATE                  ANNUAL COST ($)

                                        *** UTILITIES ***

     WATER                     49870. MGAL/YR    $  .1595/1000 GAL          8000.
     ELECTRICITY               32639. KWH/YR     $  .0266/KWH                900.
     STEAM                         0. MLBS/YR    $ 4.0920/MLBS                0.
     FUEL                          0. GAL/YR     $  .4180/GAL                 0.


                                     *** OPERATING LABOR ***

     DIRECT                     1800. HRS/YR     $14.34/HR                 25800. (A)
     SUPERVISION                 360. HRS/YR     $17.20/HR                  6200. (B)


                                  *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR                800. HRS/YR     $14.34/HR                 11500. (C)
     SUPERVISION                 160. HRS/YR     $17.20/HR                  2800. (D)
     MATERIALS                                                              6500. (E)
     SUPPLIES                                                               3300. (F)
     WATER TREATMENT                                                           0.
     SOLID WASTE
       DISPOSAL                    0. TON/YR     $ 8.25/TON                    0.

         DIRECT OPERATING COST                                             65000.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                                 9300.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                              28100.
         TOTAL OPERATING COST                                             102400.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                       .04
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED               562.16
         OPERATING COST AS PERCENT OF CAPITAL COST                           34.5
         INSTALLATION TIME IN WEEKS                                          52.
         ESTIMATED LIFE OF SYSTEM IN YEARS                                   20.
         KWH PER TON    CAPACITY                                              .0
         CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                      34900.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                 5900.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                   5900.
         TOTAL ANNUALIZED COST - RETROFIT                                149100.
                               - NEW                                     144200.
```

```
GENERAL INFORMATION:
                                                      UNITS    OPTION
     PPSES:  510.   COAL STORAGE YARD                  COKE       3

     CAPACITY:              2.834 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:     .150000 LBS/TON COAL
          ALLOWABLE:  .037500 LBS/TON COAL   EFFICIENCY:  75.0%
                       17.33  LBS/HR

     DUST COLLECTED PER DAY:         .6 TONS(DRY)

     TEMP OUT OF PROCESS:          70. F
     EXHAUST TEMPERATURE:          70. F

     SCFM FLOW:        0.    AT    70. F
     ACFM FLOW:        0.    AT    70. F

     L/G RATIO:                      .0
     PROCESS WATER FLOW:          254. GPM
     COOLING WATER FLOW:            0. GPM
     SUSPENDED SOLIDS OUT:          0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                              UNITS    OPTION
    PPSES:  510.   COAL STORAGE YARD                          COKE        3

    CONTROL SYSTEM CONFIGURATION:

          COAL RECEIVING STATION SPRAYS
          TRANSFER POINT SPRAY
          SPRAY TRUCK
          WATER PUMPING SYSTEM

    FEET OF ADDITIONAL DUCT:                 0.    DIAMETER:  0.
    TOTAL PRESSURE DROP:                     0. INCHES
    0 FANS @    0. HP EACH        SPARE FAN CAPACITY:   0.%
    OPERATING HOURS AT FULL HP:      8760.
    OPERATING HOURS AT REDUCED HP:     0.
    STACK HEIGHT:                            0.    DIAMETER:  0.
    NO. OF OVENS                           60.
    OVEN HEIGHT                             6.0 METERS
    OVEN VOLUME                          1348.  CUBIC FEET
    TONS COKE/PUSH                         24.
    AVG. COKING TIME,HRS.                  17.5
    NO. CYCLES/DAY                         82.
    BULK DENSITY                           50.  LBS/CUBIC FT.
    YIELD                                    .70
    TONS COAL/YEAR                    4047868.
```

```
CAPITAL COST:
                                                         UNITS    OPTION
    PPSES:  510.   COAL STORAGE YARD                      COKE       3

    CAPACITY:           2.834 MILLION TONS/YEAR

    TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.)

         CATEGORY                              COST IN DOLLARS

                  *** DIRECT  COST ***
         EQUIPMENT OR MATERIAL               153300.
         INSTRUMENTATION                       3800.
         PIPING                               50100.
         ELECTRICAL                           22900.
         FOUNDATIONS                           2600.
         STRUCTURAL                            4400.
         SITE WORK                              900.
         INSULATION                           26700.
         PROTECTIVE COATING                     400.
         BUILDINGS                             5500.
         EQUIPMENT/MATERIAL LABOR             10400.
              DIRECT COST SUBTOTAL                      281000.

                 *** INDIRECT  COST ***
         FIELD OVERHEAD                       24100.
         CONTRACTORS FEE                      14800.
         ENGINEERING                          42700.
         FREIGHT                               1900.
         OFFSITE WORK                           300.
         TAXES                                 9000.
         SHAKEDOWN                             1600.
         SPARES                                1600.
         CONTINGENCY                          62200.
              INDIRECT COST SUBTOTAL                    158200.

              INTEREST DURING INSTALLATION               13500.

              TOTAL COST                                452700.

              TOTAL COST WITH RETROFIT                  525100.
```

```
OPERATING COST:
                                                      UNITS    OPTION
        PPSES:  510.   COAL STORAGE YARD               COKE       3

        CAPACITY:        2.834 MILLION TONS/YEAR

        CATEGORY                  QUANTITY          RATE                  ANNUAL COST ($)

                                        *** UTILITIES ***

        WATER                     74805. MGAL/YR    $  .1595/1000 GAL        11900.
        ELECTRICITY               48959. KWH/YR     $  .0266/KWH              1300.
        STEAM                         0. MLBS/YR    $ 4.0920/MLBS                0.
        FUEL                          0. GAL/YR     $  .4180/GAL                 0.

                                     *** OPERATING LABOR ***

        DIRECT                     1800. HRS/YR     $14.34/HR                25800. (A)
        SUPERVISION                 360. HRS/YR     $17.20/HR                 6200. (B)

                                 *** MAINTENANCE & SUPPLIES ***

        DIRECT LABOR               1200. HRS/YR     $14.34/HR                17200. (C)
        SUPERVISION                 240. HRS/YR     $17.20/HR                 4100. (D)
        MATERIALS                                                             9300. (E)
        SUPPLIES                                                              4900. (F)
        WATER TREATMENT                                                          0.
        SOLID WASTE
          DISPOSAL                    0. TON/YR     $ 8.25/TON                   0.

            DIRECT OPERATING COST                                            80700.

            PAYROLL OVERHEAD =20.0% OF A+B+C+D                               10700.
            PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                             33800.
            TOTAL OPERATING COST                                            125200.
            OPERATING COST IN DOLLARS PER TON   PRODUCTION                       .04
            OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED               549.86
            OPERATING COST AS PERCENT OF CAPITAL COST                          23.8
            INSTALLATION TIME IN WEEKS                                         52.
            ESTIMATED LIFE OF SYSTEM IN YEARS                                  20.
            KWH PER TON    CAPACITY                                             .0
            CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                       61700.
            ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                 10500.
            PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                   10500.
            TOTAL ANNUALIZED COST - RETROFIT                                207900.
                                  - NEW                                     196600.
```

```
GENERAL INFORMATION:
                                                           UNITS   OPTION
     PPSES:  510.   COAL STORAGE YARD                       COKE      4

     CAPACITY:          2.834 MILLION TONS/YEAR

     PARTICULATE
           LOAD IN:     .150000 LBS/TON COAL
           ALLOWABLE:   .015000 LBS/TON COAL   EFFICIENCY:  90.0%
                          6.93  LBS/HR

     DUST COLLECTED PER DAY:          .7 TONS(DRY)

     TEMP OUT OF PROCESS:          70. F
     EXHAUST TEMPERATURE:          70. F

     SCFM FLOW:         0.    AT    70. F
     ACFM FLOW:         0.    AT    70. F

     L/G RATIO:                      .0
     PROCESS WATER FLOW:          680. GPM
     COOLING WATER FLOW:            0. GPM
     SUSPENDED SOLIDS OUT:          0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                      UNITS    OPTION
     PPSES:  510.   COAL STORAGE YARD                  COKE       4


     CONTROL SYSTEM CONFIGURATION:

          COAL RECEIVING STATION SPRAYS
          SPRAY TRUCK
          COAL PILE PERIMETER SPRAY
          WATER PUMPING SYSTEM


     FEET OF ADDITIONAL DUCT:              0.     DIAMETER:  0.
     TOTAL PRESSURE DROP:                  0. INCHES
     0 FANS @     0. HP EACH          SPARE FAN CAPACITY:    0.%
     OPERATING HOURS AT FULL HP:        8760.
     OPERATING HOURS AT REDUCED HP:        0.
     STACK HEIGHT:                         0.     DIAMETER:  0.
     NO. OF OVENS                         60.
     OVEN HEIGHT                           6.0 METERS
     OVEN VOLUME                        1346.  CUBIC FEET
     TONS COKE/PUSH                       24.
     AVG. COKING TIME,HRS.                17.5
     NO. CYCLES/DAY                       82.
     BULK DENSITY                         50.  LBS/CUBIC FT.
     YIELD                                  .70
     TONS COAL/YEAR                  4047868.
```

```
CAPITAL COST:
                                                         UNITS   OPTION
     PPSES:  510.   COAL STORAGE YARD                    COKE       4

     CAPACITY:          2.834 MILLION TONS/YEAR

     TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST..

          CATEGORY                                COST IN DOLLARS

                   *** DIRECT  COST ***
          EQUIPMENT OR MATERIAL                1240100.
          INSTRUMENTATION                         3800.
          PIPING                                582100.
          ELECTRICAL                             78100.
          FOUNDATIONS                            20400.
          STRUCTURAL                              4400.
          SITE WORK                              15300.
          INSULATION                            347000.
          PROTECTIVE COATING                       700.
          BUILDINGS                              96400.
          EQUIPMENT/MATERIAL LABOR               72300.
               DIRECT COST SUBTOTAL                        2460600.

                  *** INDIRECT  COST ***
          FIELD OVERHEAD                        389900.
          CONTRACTORS FEE                       239800.
          ENGINEERING                           235600.
          FREIGHT                                13800.
          OFFSITE WORK                           68100.
          TAXES                                  63200.
          SHAKEDOWN                              17500.
          SPARES                                 12700.
          CONTINGENCY                           687500.
               INDIRECT COST SUBTOTAL                      1728100.

               INTEREST DURING INSTALLATION                 308700.

               TOTAL COST                                  4497400.

               TOTAL COST WITH RETROFIT                    4974300.
```

```
OPERATING COST:
                                                      UNITS   OPTION
     PPSES:  510.   COAL STORAGE YARD                  COKE      4

     CAPACITY:           2.834 MILLION TONS/YEAR

     CATEGORY                QUANTITY         RATE                 ANNUAL COST ($)

                                  *** UTILITIES ***

     WATER                200046. MGAL/YR    $  .1595/1000 GAL        31900.
     ELECTRICITY          130928. KWH/YR     $  .0266/KWH              3500.
     STEAM                     0. MLBS/YR    $ 4.0920/MLBS                0.
     FUEL                      0. GAL/YR     $  .4180/GAL                 0.


                               *** OPERATING LABOR ***

     DIRECT                40590. HRS/YR     $14.34/HR               582200. (A)
     SUPERVISION            8118. HRS/YR     $17.20/HR               139700. (B)


                           *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR           6378. HRS/YR     $14.34/HR                91500. (C)
     SUPERVISION            1276. HRS/YR     $17.20/HR                21900. (D)
     MATERIALS                                                        46500. (E)
     SUPPLIES                                                         24700. (F)
     WATER TREATMENT                                                      0.
     SOLID WASTE
       DISPOSAL                0. TON/YR     $ 8.25/TON                   0.

         DIRECT OPERATING COST                                       941900.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                          167100.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                        453300.
         TOTAL OPERATING COST                                       1562300.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                   .55
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED          5717.87
         OPERATING COST AS PERCENT OF CAPITAL COST                       31.4
         INSTALLATION TIME IN WEEKS                                      80.
         ESTIMATED LIFE OF SYSTEM IN YEARS                               20.
         KWH PER TON    CAPACITY                                           .0
         CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                  584300.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)             99500.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)               99500.
         TOTAL ANNUALIZED COST - RETROFIT                           2345600.
                               - NEW                                2270400.
```

```
GENERAL INFORMATION:
                                                      UNITS    OPTION
     PPSES:  511.   PIPELINE CHARGING                  COKE       2

     CAPACITY:              .992 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:      .016000 LBS/TON COAL
          ALLOWABLE:    .000160 LBS/TON COAL   EFFICIENCY:  99.0%
                            .03  LBS/HR

     BSO
          LOAD IN:      .019000 LBS/TON COAL
          ALLOWABLE:    .000190 LBS/TON COAL   EFFICIENCY:  99.0%
                            .03  LBS/HR

     BAP
          LOAD IN:      .000035 LBS/TON COAL
          ALLOWABLE:    .000000 LBS/TON COAL   EFFICIENCY:  99.0%
                            .00  LBS/HR

     BENZENE
          LOAD IN:      .008000 LBS/TON COAL
          ALLOWABLE:    .000080 LBS/TON COAL   EFFICIENCY:  99.0%
                            .01  LBS/HR

     DUST COLLECTED PER DAY:          .0 TONS(DRY)

     TEMP OUT OF PROCESS:          180. F
     EXHAUST TEMPERATURE:          180. F

     SCFM FLOW:         0.    AT    70. F
     ACFM FLOW:         0.    AT   180. F

     L/G RATIO:                        .0
     PROCESS WATER FLOW:             0. GPM
     COOLING WATER FLOW:             0. GPM
     SUSPENDED SOLIDS OUT:           0. MG/L      %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                        UNITS   OPTION
    PPSES:  511.   PIPELINE CHARGING                     COKE      2

    CONTROL SYSTEM CONFIGURATION:

         TOPSIDE AND PIPELINE MAINT.

    FEET OF ADDITIONAL DUCT:              0.     DIAMETER:  0.
    TOTAL PRESSURE DROP:                  0. INCHES
    0 FANS @    0. HP EACH        SPARE FAN CAPACITY:   0.%
    OPERATING HOURS AT FULL HP:     8760.
    OPERATING HOURS AT REDUCED HP:    0.
    STACK HEIGHT:                         0.     DIAMETER:  0.
    NO. OF OVENS                         60.
    OVEN HEIGHT                           6.0 METERS
    OVEN VOLUME                        1346.  CUBIC FEET
    TONS COKE/PUSH                       24.
    AVG. COKING TIME,HRS.                12.5
    NO. CYCLES/DAY                      115.
    BULK DENSITY                         50.  LBS/CUBIC FT.
    YIELD                                  .70
    TONS COAL/YEAR                  1416755.
```

```
OPERATING COST:

     PPSES:  511.   PIPELINE CHARGING                 UNITS    OPTION
                                                       COKE       2

     CAPACITY:              .992 MILLION TONS/YEAR

     CATEGORY               QUANTITY          RATE                 ANNUAL COST ($)

                                   *** UTILITIES ***

     WATER                    0. MGAL/YR      $  .1595/1000 GAL            0.
     ELECTRICITY              0. KWH/YR       $  .0266/KWH                 0.
     STEAM                    0. MLBS/YR      $ 4.0920/MLBS                0.
     FUEL                     0. GAL/YR       $  .4180/GAL                 0.

                                *** OPERATING LABOR ***

     DIRECT                 8760. HRS/YR     $14.34/HR               125700. (A)
     SUPERVISION            1752. HRS/YR     $17.20/HR                30100. (B)

                              *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR           5900. HRS/YR     $14.34/HR                84600. (C)
     SUPERVISION            1180. HRS/YR     $17.20/HR                20300. (D)
     MATERIALS                                                        42300. (E)
     SUPPLIES                                                         22100. (F)
     WATER TREATMENT                                                      0.
     SOLID WASTE
       DISPOSAL               0. TON/YR      $ 8.25/TON                   0.

         DIRECT OPERATING COST                                       325100.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                           52100.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                        162600.
         TOTAL OPERATING COST                                        539800.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                  .54
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED        48107.55
         OPERATING COST AS PERCENT OF CAPITAL COST                        .0
         INSTALLATION TIME IN WEEKS                                       8.
         ESTIMATED LIFE OF SYSTEM IN YEARS                               99.
         KWH PER TON    CAPACITY                                          .0
         CAPITAL RECOVERY (10.00% OF TOTAL CAPITAL)                       0.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                 0.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                   0.
         TOTAL ANNUALIZED COST - RETROFIT                            539800.
                               - NEW                                 539800.
```

```
GENERAL INFORMATION:
                                                   UNITS   OPTION
     PPSES:  512.   REDLER CHARGING                 COKE      2

     CAPACITY:               .992 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:      .010000 LBS/TON COAL
          ALLOWABLE:    .000100 LBS/TON COAL   EFFICIENCY:  99.0%
                            .02  LBS/HR

     BSO
          LOAD IN:      .006000 LBS/TON COAL
          ALLOWABLE:    .000060 LBS/TON COAL   EFFICIENCY:  99.0%
                            .01  LBS/HR

     BAP
          LOAD IN:      .000011 LBS/TON COAL
          ALLOWABLE:    .000000 LBS/TON COAL   EFFICIENCY:  99.0%
                            .00  LBS/HR

     BENZENE
          LOAD IN:      .004900 LBS/TON COAL
          ALLOWABLE:    .000049 LBS/TON COAL   EFFICIENCY:  99.0%
                            .01  LBS/HR

     DUST COLLECTED PER DAY:          .0 TONS(DRY)

     TEMP OUT OF PROCESS:         180. F
     EXHAUST TEMPERATURE:         180. F

     SCFM FLOW:         0.    AT    70. F
     ACFM FLOW:         0.    AT   180. F

     L/G RATIO:                         .0
     PROCESS WATER FLOW:               0. GPM
     COOLING WATER FLOW:               0. GPM
     SUSPENDED SOLIDS OUT:             0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                    UNITS   OPTION
    PPSES:  512.   REDLER CHARGING                   COKE      2


    CONTROL SYSTEM CONFIGURATION:

         REDLER SYSTEM MAINT.

    FEET OF ADDITIONAL DUCT:             0.    DIAMETER:  0.
    TOTAL PRESSURE DROP:                 0. INCHES
    0 FANS @    0. HP EACH       SPARE FAN CAPACITY:   0.%
    OPERATING HOURS AT FULL HP:     8760.
    OPERATING HOURS AT REDUCED HP:       0.
    STACK HEIGHT:                        0.    DIAMETER:  0.
    NO. OF OVENS                        60.
    OVEN HEIGHT                          6.0 METERS
    OVEN VOLUME                       1348.  CUBIC FEET
    TONS COKE/PUSH                      24.
    AVG. COKING TIME,HRS.               12.5
    NO. CYCLES/DAY                     115.
    BULK DENSITY                        50.  LBS/CUBIC FT.
    YIELD                                .70
    TONS COAL/YEAR                 1416755.
```

```
OPERATING COST:

     PPSES:  512.   REDLER CHARGING                  UNITS    OPTION
                                                      COKE       2

     CAPACITY:              .992 MILLION TONS/YEAR

     CATEGORY               QUANTITY          RATE                  ANNUAL COST ($)

                                    *** UTILITIES ***

     WATER                      0. MGAL/YR     $  .1595/1000 GAL            0.
     ELECTRICITY                0. KWH/YR      $  .0266/KWH                 0.
     STEAM                      0. MLBS/YR     $ 4.0920/MLBS                0.
     FUEL                       0. GAL/YR      $  .4180/GAL                 0.

                               *** OPERATING LABOR ***

     DIRECT                 8760. HRS/YR      $14.34/HR              125700. (A)
     SUPERVISION            1752. HRS/YR      $17.20/HR               30100. (B)

                          *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR           2000. HRS/YR      $14.34/HR               28700. (C)
     SUPERVISION             400. HRS/YR      $17.20/HR                6900. (D)
     MATERIALS                                                        14300. (E)
     SUPPLIES                                                          7500. (F)
     WATER TREATMENT                                                      0.
     SOLID WASTE
       DISPOSAL                 0. TON/YR     $ 8.25/TON                  0.

          DIRECT OPERATING COST                                      213200.

          PAYROLL OVERHEAD =20.0% OF A+B+C+D                          38300.
          PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                       106600.
          TOTAL OPERATING COST                                       358100.
          OPERATING COST IN DOLLARS PER TON   PRODUCTION                 .36
          OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED       51062.80
          OPERATING COST AS PERCENT OF CAPITAL COST                       .0
          INSTALLATION TIME IN WEEKS                                      8.
          ESTIMATED LIFE OF SYSTEM IN YEARS                              99.
          KWH PER TON   CAPACITY                                          .0
          CAPITAL RECOVERY (10.00% OF TOTAL CAPITAL)                      0.
          ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                0.
          PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                  0.
          TOTAL ANNUALIZED COST - RETROFIT                           358100.
                                - NEW                                358100.
```

```
GENERAL INFORMATION:
                                                             UNITS    OPTION
     PPSES:  513.   HOT LARRY CAR CHARGING                   COKE       2

     CAPACITY:                .992 MILLION TONS/YEAR

     PARTICULATE
           LOAD IN:      .017000 LBS/TON COAL
           ALLOWABLE:    .000170 LBS/TON COAL    EFFICIENCY:  99.0%
                             .03  LBS/HR

     BSO
           LOAD IN:      .019000 LBS/TON COAL
           ALLOWABLE:    .000190 LBS/TON COAL    EFFICIENCY:  99.0%
                             .03  LBS/HR

     BAP
           LOAD IN:      .000035 LBS/TON COAL
           ALLOWABLE:    .000000 LBS/TON COAL    EFFICIENCY:  99.0%
                             .00  LBS/HR

     BENZENE
           LOAD IN:      .008000 LBS/TON COAL
           ALLOWABLE:    .000080 LBS/TON COAL    EFFICIENCY:  99.0%
                             .01  LBS/HR

     DUST COLLECTED PER DAY:          .0 TONS(DRY)

     TEMP OUT OF PROCESS:          180. F
     EXHAUST TEMPERATURE:          180. F

     SCFM FLOW:         0.    AT    70. F
     ACFM FLOW:         0.    AT   180. F

     L/G RATIO:                       .0
     PROCESS WATER FLOW:            0. GPM
     COOLING WATER FLOW:            0. GPM
     SUSPENDED SOLIDS OUT:          0. MG/L      %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                              UNITS   OPTION
    PPSES:  513.   HOT LARRY CAR CHARGING      COKE      2

    CONTROL SYSTEM CONFIGURATION:

         HOT LARRY CAR -TOPSIDE

    FEET OF ADDITIONAL DUCT:          0.    DIAMETER:  0.
    TOTAL PRESSURE DROP:              0. INCHES
    0 FANS @    0. HP EACH       SPARE FAN CAPACITY:   0.%
    OPERATING HOURS AT FULL HP:    8760.
    OPERATING HOURS AT REDUCED HP:    0.
    STACK HEIGHT:                     0.    DIAMETER:  0.
    NO. OF OVENS                     60.
    OVEN HEIGHT                        6.0 METERS
    OVEN VOLUME                    1348.  CUBIC FEET
    TONS COKE/PUSH                   24.
    AVG. COKING TIME,HRS.            12.5
    NO. CYCLES/DAY                  115.
    BULK DENSITY                     50.  LBS/CUBIC FT.
    YIELD                              .70
    TONS COAL/YEAR              1416755.
```

```
OPERATING COST:
                                                   UNITS   OPTION
     PPSES:  513.   HOT LARRY CAR CHARGING         COKE      2

     CAPACITY:           .992 MILLION TONS/YEAR

     CATEGORY                QUANTITY         RATE                    ANNUAL COST ($)

                                  *** UTILITIES ***

     WATER                      0. MGAL/YR    $   .1595/1000 GAL              0.
     ELECTRICITY                0. KWH/YR     $   .0266/KWH                   0.
     STEAM                      0. MLBS/YR    $ 4.0920/MLBS                   0.
     FUEL                       0. GAL/YR     $   .4180/GAL                   0.

                              *** OPERATING LABOR ***

     DIRECT                  8760. HRS/YR     $14.34/HR                  125700. (A)
     SUPERVISION             1752. HRS/YR     $17.20/HR                   30100. (B)

                           *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR               0. HRS/YR     $14.34/HR                       0. (C)
     SUPERVISION                0. HRS/YR     $17.20/HR                       0. (D)
     MATERIALS                                                                0. (E)
     SUPPLIES                                                                 0. (F)
     WATER TREATMENT                                                          0.
     SOLID WASTE
       DISPOSAL                 0. TON/YR     $ 8.25/TON                      0.

         DIRECT OPERATING COST                                           155800.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                               31200.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                             77900.
         TOTAL OPERATING COST                                            264900.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                      .27
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED           22219.45
         OPERATING COST AS PERCENT OF CAPITAL COST                            .0
         INSTALLATION TIME IN WEEKS                                          8.
         ESTIMATED LIFE OF SYSTEM IN YEARS                                  99.
         KWH PER TON    CAPACITY                                             .0
         CAPITAL RECOVERY (10.00% OF TOTAL CAPITAL)                         0.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                   0.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                     0.
         TOTAL ANNUALIZED COST - RETROFIT                              264900.
                               - NEW                                   264900.
```

```
GENERAL INFORMATION:

     PPSES:  514.   BY-PRODUCTS PLANT                       UNITS    OPTION
                                                             COKE       2
     CAPACITY:             2.834 MILLION TONS/YEAR

     BSO
          LOAD IN:      .300000 LBS/TON COAL
          ALLOWABLE:    .060000 LBS/TON COAL    EFFICIENCY:  80.0%
                         27.73  LBS/HR

     BENZENE
          LOAD IN:      .200000 LBS/TON COAL
          ALLOWABLE:    .040000 LBS/TON COAL    EFFICIENCY:  80.0%
                         18.48  LBS/HR

     DUST COLLECTED PER DAY:          .0 TONS(DRY)

     TEMP OUT OF PROCESS:          100. F
     EXHAUST TEMPERATURE:          100. F

     SCFM FLOW:         0.    AT    70. F
     ACFM FLOW:         0.    AT   100. F

     L/G RATIO:                      .0
     PROCESS WATER FLOW:           0. GPM
     COOLING WATER FLOW:           0. GPM
     SUSPENDED SOLIDS OUT:         0. MG/L      %SOLIDS:     .0
```

```
GENERAL INFORMATION:

     PPSES:  514.   BY-PRODUCTS PLANT               UNITS   OPTION
                                                     COKE      2

     CONTROL SYSTEM CONFIGURATION:

          BY-PRODUCT CONTROLS

     FEET OF ADDITIONAL DUCT:              0.     DIAMETER:  0.
     TOTAL PRESSURE DROP:                  0. INCHES
     0 FANS @     0. HP EACH        SPARE FAN CAPACITY:   0.%
     OPERATING HOURS AT FULL HP:      8760.
     OPERATING HOURS AT REDUCED HP:      0.
     STACK HEIGHT:                         0.     DIAMETER:  0.
     NO. OF OVENS                         60.
     OVEN HEIGHT                           6.0 METERS
     OVEN VOLUME                        1348.  CUBIC FEET
     TONS COKE/PUSH                       24.
     AVG. COKING TIME,HRS.                17.5
     NO. CYCLES/DAY                       82.
     BULK DENSITY                         50.  LBS/CUBIC FT.
     YIELD                                 .70
     TONS COAL/YEAR                  4047868.
```

```
OPERATING COST:

                                                        UNITS    OPTION
     PPSES:  514.   BY-PRODUCTS PLANT                    COKE       2

     CAPACITY:          2.834 MILLION TONS/YEAR

     CATEGORY                QUANTITY          RATE                   ANNUAL COST ($)

                                   *** UTILITIES ***

     WATER                      0. MGAL/YR     $  .1595/1000 GAL           0.
     ELECTRICITY                0. KWH/YR      $  .0266/KWH                0.
     STEAM                      0. MLBS/YR     $ 4.0920/MLBS               0.
     FUEL                       0. GAL/YR      $  .4180/GAL                0.

                                *** OPERATING LABOR ***

     DIRECT                     0. HRS/YR      $14.34/HR                   0. (A)
     SUPERVISION                0. HRS/YR      $17.20/HR                   0. (B)

                              *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR            8760. HRS/YR      $14.34/HR              125700. (C)
     SUPERVISION             1752. HRS/YR      $17.20/HR               30100. (D)
     MATERIALS                                                             0. (E)
     SUPPLIES                                                          23400. (F)
     WATER TREATMENT                                                       0.
     SOLID WASTE
       DISPOSAL                 0. TON/YR      $ 8.25/TON                  0.

         DIRECT OPERATING COST                                        179200.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                            31200.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                          89600.
         TOTAL OPERATING COST                                         300000.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                   .11
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED        25163.59
         OPERATING COST AS PERCENT OF CAPITAL COST                         .0
         INSTALLATION TIME IN WEEKS                                        8.
         ESTIMATED LIFE OF SYSTEM IN YEARS                                99.
         KWH PER TON    CAPACITY                                           .0
         CAPITAL RECOVERY (10.00% OF TOTAL CAPITAL)                        0.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                  0.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                    0.
         TOTAL ANNUALIZED COST - RETROFIT                             300000.
                               - NEW                                  300000.
```

```
GENERAL INFORMATION:

                                                      UNITS    OPTION
     PPSES:  515.   COMBUSTION STACK - NEW            COKE        2

     CAPACITY:            .708 MILLION TONS/YEAR

     PARTICULATE
          LOAD IN:      .130000 LBS/TON COAL
          ALLOWABLE:    .026000 LBS/TON COAL    EFFICIENCY:  80.0%
                           3.00  LBS/HR

     BSO
          LOAD IN:      .000600 LBS/TON COAL
          ALLOWABLE:    .000120 LBS/TON COAL    EFFICIENCY:  80.0%
                            .01  LBS/HR

     BAP
          LOAD IN:      .000006 LBS/TON COAL
          ALLOWABLE:    .000001 LBS/TON COAL    EFFICIENCY:  80.0%
                            .00  LBS/HR

     DUST COLLECTED PER DAY:         .1 TONS(DRY)

     TEMP OUT OF PROCESS:         450. F
     EXHAUST TEMPERATURE:         450. F

     SCFM FLOW:   67000.    AT     70. F
     ACFM FLOW:  115000.    AT    450. F

     L/G RATIO:                      .0
     PROCESS WATER FLOW:            0. GPM
     COOLING WATER FLOW:            0. GPM
     SUSPENDED SOLIDS OUT:          0. MG/L     %SOLIDS:     .0
```

```
GENERAL INFORMATION:
                                                      UNITS   OPTION
     PPSES:  515.   COMBUSTION STACK - NEW            COKE       2

     CONTROL SYSTEM CONFIGURATION:

          HEATING CONTROL AND PATCHING

     FEET OF ADDITIONAL DUCT:                 0.    DIAMETER:  6.
     TOTAL PRESSURE DROP:                     0. INCHES
     0 FANS @    0. HP EACH         SPARE FAN CAPACITY:   0.%
     OPERATING HOURS AT FULL HP:     8760.
     OPERATING HOURS AT REDUCED HP:     0.
     STACK HEIGHT:                            0.    DIAMETER:  0.
     NO. OF OVENS                            60.
     OVEN HEIGHT                              6.0 METERS
     OVEN VOLUME                           1348.  CUBIC FEET
     TONS COKE/PUSH                          24.
     AVG. COKING TIME,HRS.                   17.5
     NO. CYCLES/DAY                          82.
     BULK DENSITY                            50.  LBS/CUBIC FT.
     YIELD                                     .70
     TONS COAL/YEAR                    1011967.
```

```
OPERATING COST:
                                                   UNITS    OPTION
     PPSES:  515.   COMBUSTION STACK - NEW          COKE       2

     CAPACITY:            .708 MILLION TONS/YEAR

     CATEGORY                 QUANTITY          RATE                ANNUAL COST ($)

                                 *** UTILITIES ***

     WATER                       0. MGAL/YR    $  .1595/1000 GAL           0.
     ELECTRICITY                 0. KWH/YR     $  .0266/KWH                0.
     STEAM                       0. MLBS/YR    $ 4.0920/MLBS               0.
     FUEL                        0. GAL/YR     $  .4180/GAL                0.

                              *** OPERATING LABOR ***

     DIRECT                   8760. HRS/YR     $14.34/HR              125700. (A)
     SUPERVISION              1752. HRS/YR     $17.20/HR               30100. (B)

                          *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR             5900. HRS/YR     $14.34/HR               84600. (C)
     SUPERVISION              1180. HRS/YR     $17.20/HR               20300. (D)
     MATERIALS                                                         21200. (E)
     SUPPLIES                                                          18900. (F)
     WATER TREATMENT                                                       0.
     SOLID WASTE
       DISPOSAL                  0. TON/YR     $ 8.25/TON                  0.

          DIRECT OPERATING COST                                       300800.

          PAYROLL OVERHEAD =20.0% OF A+B+C+D                           52100.
          PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                        150400.
          TOTAL OPERATING COST                                        503300.
          OPERATING COST IN DOLLARS PER TON   PRODUCTION                  .71
          OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED         9564.39
          OPERATING COST AS PERCENT OF CAPITAL COST                        .0
          INSTALLATION TIME IN WEEKS                                      8.
          ESTIMATED LIFE OF SYSTEM IN YEARS                              99.
          KWH PER TON    CAPACITY                                          .0
          CAPITAL RECOVERY (10.00% OF TOTAL CAPITAL)                      0.
          ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                0.
          PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                  0.
          TOTAL ANNUALIZED COST - RETROFIT                           503300.
                                - NEW                                503300.
```

```
GENERAL INFORMATION:
                                                         UNITS    OPTION
     PPSES:  516.   QUENCHING - DIRTY WATER              COKE       2

     CAPACITY:            2.834 MILLION TONS/YEAR

     PARTICULATE
           LOAD IN:     3.200000 LBS/TON COAL
           ALLOWABLE:    .960000 LBS/TON COAL    EFFICIENCY:  70.0%
                         443.60  LBS/HR

     BSO
           LOAD IN:      .006400 LBS/TON COAL
           ALLOWABLE:    .001920 LBS/TON COAL    EFFICIENCY:  70.0%
                             .89  LBS/HR

     BAP
           LOAD IN:      .000310 LBS/TON COAL
           ALLOWABLE:    .000093 LBS/TON COAL    EFFICIENCY:  70.0%
                             .04  LBS/HR

     BENZENE
           LOAD IN:      .000260 LBS/TON COAL
           ALLOWABLE:    .000260 LBS/TON COAL    EFFICIENCY:     .0%
                             .12  LBS/HR

     DUST COLLECTED PER DAY:       12.4 TONS(DRY)

     TEMP OUT OF PROCESS:         200. F
     EXHAUST TEMPERATURE:         200. F

     SCFM FLOW:         0.    AT    70. F
     ACFM FLOW:         0.    AT   200. F

     L/G RATIO:                      .0
     PROCESS WATER FLOW:            0. GPM
     COOLING WATER FLOW:            0. GPM
     SUSPENDED SOLIDS OUT:          0. MG/L     %SOLIDS:     .0
```

```
CAPITAL COST:

                                                        UNITS   OPTION
     PPSES:  516.   QUENCHING - DIRTY WATER              COKE       2

     CAPACITY:          2.834 MILLION TONS/YEAR

     TOTAL COST      (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.

          CATEGORY                                COST IN DOLLARS

                     *** DIRECT  COST ***
          EQUIPMENT OR MATERIAL                  114100.
          INSTRUMENTATION                             0.
          PIPING                                  30800.
          ELECTRICAL                               6200.
          FOUNDATIONS                               900.
          STRUCTURAL                                  0.
          SITE WORK                                 600.
          INSULATION                                  0.
          PROTECTIVE COATING                        900.
          BUILDINGS                                   0.
          EQUIPMENT/MATERIAL LABOR                80300.
               DIRECT COST SUBTOTAL                          233800.

                    *** INDIRECT  COST ***
          FIELD OVERHEAD                          45400.
          CONTRACTORS FEE                         27900.
          ENGINEERING                             35100.
          FREIGHT                                  4400.
          OFFSITE WORK                                0.
          TAXES                                    5700.
          SHAKEDOWN                                1300.
          SPARES                                   3500.
          CONTINGENCY                             71400.
               INDIRECT COST SUBTOTAL                        194700.

               INTEREST DURING INSTALLATION                   10700.

               TOTAL COST                                    439200.

               TOTAL COST WITH RETROFIT                      571000.
```

```
OPERATING COST:

     PPSES:  516.   QUENCHING - DIRTY WATER      UNITS    OPTION
                                                 COKE       2
     CAPACITY:          2.834 MILLION TONS/YEAR

     CATEGORY                QUANTITY          RATE                       ANNUAL COST ($)

                                   *** UTILITIES ***

     WATER                       0. MGAL/YR     $  .1595/1000 GAL             0.
     ELECTRICITY                 0. KWH/YR      $  .0266/KWH                  0.
     STEAM                       0. MLBS/YR     $ 4.0920/MLBS                 0.
     FUEL                        0. GAL/YR      $  .4180/GAL                  0.

                                 *** OPERATING LABOR ***

     DIRECT                      0. HRS/YR      $14.34/HR                     0. (A)
     SUPERVISION                 0. HRS/YR      $17.20/HR                     0. (B)

                              *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR             1200. HRS/YR      $14.34/HR                 17200. (C)
     SUPERVISION               240. HRS/YR      $17.20/HR                  4100. (D)
     MATERIALS                                                             8600. (E)
     SUPPLIES                                                              4500. (F)
     WATER TREATMENT                                                          0.
     SOLID WASTE
       DISPOSAL               9067. TON/YR      $ 8.25/TON                74800.

          DIRECT OPERATING COST                                          109200.

          PAYROLL OVERHEAD =20.0% OF A+B+C+D                               4300.
          PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                            17200.
          TOTAL OPERATING COST                                           130700.
          OPERATING COST IN DOLLARS PER TON   PRODUCTION                     .05
          OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED              28.83
          OPERATING COST AS PERCENT OF CAPITAL COST                         22.9
          INSTALLATION TIME IN WEEKS                                        26.
          ESTIMATED LIFE OF SYSTEM IN YEARS                                 20.
          KWH PER TON    CAPACITY                                             .0
          CAPITAL RECOVERY (11.75% OF TOTAL CAPITAL)                     67100.
          ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)               11400.
          PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                 11400.
          TOTAL ANNUALIZED COST - RETROFIT                              220600.
                                - NEW                                   199900.
```

```
GENERAL INFORMATION:
                                                    UNITS    OPTION
    PPSES:  516.   QUENCHING - DIRTY WATER          COKE       3

    CAPACITY:           2.834 MILLION TONS/YEAR

    PARTICULATE
         LOAD IN:    3.200000 LBS/TON COAL
         ALLOWABLE:   .480000 LBS/TON COAL    EFFICIENCY:  85.0%
                     221.80   LBS/HR

    BSO
         LOAD IN:     .006400 LBS/TON COAL
         ALLOWABLE:   .001600 LBS/TON COAL    EFFICIENCY:  75.0%
                         .74  LBS/HR

    BAP
         LOAD IN:     .000310 LBS/TON COAL
         ALLOWABLE:   .000062 LBS/TON COAL    EFFICIENCY:  80.0%
                         .03  LBS/HR

    BENZENE
         LOAD IN:     .000260 LBS/TON COAL
         ALLOWABLE:   .000065 LBS/TON COAL    EFFICIENCY:  75.0%
                         .03  LBS/HR

    DUST COLLECTED PER DAY:       15.1 TONS(DRY)

    TEMP OUT OF PROCESS:         200. F
    EXHAUST TEMPERATURE:         200. F

    SCFM FLOW:          0.    AT    70. F
    ACFM FLOW:          0.    AT   200. F

    L/G RATIO:                      .0
    PROCESS WATER FLOW:         1213. GPM
    COOLING WATER FLOW:            0. GPM
    SUSPENDED SOLIDS OUT:       1707. MG/L      %SOLIDS:     .2
```

```
GENERAL INFORMATION:
                                                    UNITS    OPTION
    PPSES:  516.   QUENCHING - DIRTY WATER          COKE        3

    CONTROL SYSTEM CONFIGURATION:

         QUENCH TOWER BAFFLES
         COKE PLANT WASTEWATER TREATMENT

    FEET OF ADDITIONAL DUCT:             0.    DIAMETER:  0.
    TOTAL PRESSURE DROP:                 0. INCHES
    0 FANS @    0. HP EACH       SPARE FAN CAPACITY:   0.%
    OPERATING HOURS AT FULL HP:     8760.
    OPERATING HOURS AT REDUCED HP:     0.
    STACK HEIGHT:                        0.    DIAMETER:  0.
    NO. OF OVENS                        60.
    OVEN HEIGHT                          6.0 METERS
    OVEN VOLUME                       1348.  CUBIC FEET
    TONS COKE/PUSH                      24.
    AVG. COKING TIME,HRS.               17.5
    NO. CYCLES/DAY                      82.
    BULK DENSITY                        50.  LBS/CUBIC FT.
    YIELD                                .70
    TONS COAL/YEAR                 4047868.
```

```
CAPITAL COST:
                                                     UNITS    OPTION
    PPSES:  516.   QUENCHING - DIRTY WATER           COKE       3

    CAPACITY:          2.834 MILLION TONS/YEAR

    TOTAL COST      (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4Q78 COST.

         CATEGORY                               COST IN DOLLARS

                 *** DIRECT  COST ***
         EQUIPMENT OR MATERIAL              3141700.
         INSTRUMENTATION                     424400.
         PIPING                              745400.
         ELECTRICAL                          233900.
         FOUNDATIONS                         131400.
         STRUCTURAL                          130500.
         SITE WORK                           166600.
         INSULATION                          121100.
         PROTECTIVE COATING                   49200.
         BUILDINGS                           546000.
         EQUIPMENT/MATERIAL LABOR            321600.
              DIRECT COST SUBTOTAL                        6011800.

                 *** INDIRECT  COST ***
         FIELD OVERHEAD                     1034500.
         CONTRACTORS FEE                     228100.
         ENGINEERING                         633400.
         FREIGHT                              28500.
         OFFSITE WORK                        149600.
         TAXES                               126300.
         SHAKEDOWN                           249800.
         SPARES                              124100.
         CONTINGENCY                        1559900.
              INDIRECT COST SUBTOTAL                      4134200.

              INTEREST DURING INSTALLATION                 982500.

              TOTAL COST                                 11128500.

              TOTAL COST WITH RETROFIT                   13398200.
```

```
OPERATING COST:
                                                    UNITS    OPTION
     PPSES:  516.   QUENCHING - DIRTY WATER        COKE       3

     CAPACITY:          2.834 MILLION TONS/YEAR

     CATEGORY                QUANTITY         RATE                 ANNUAL COST ($)

                             *** UTILITIES ***

     WATER                      0. MGAL/YR    $  .1595/1000 GAL           0.
     ELECTRICITY          4250262. KWH/YR     $  .0266/KWH           113100.
     STEAM                1062566. MLBS/YR    $ 4.0920/MLBS         4348000.
     FUEL                 2312143. GAL/YR     $  .4180/GAL           966500.


                          *** OPERATING LABOR ***

     DIRECT                  8760. HRS/YR     $14.34/HR              125700. (A)
     SUPERVISION             1752. HRS/YR     $17.20/HR               30100. (B)


                       *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR           17200. HRS/YR     $14.34/HR              246700. (C)
     SUPERVISION             3440. HRS/YR     $17.20/HR               59200. (D)
     MATERIALS                                                       238100. (E)
     SUPPLIES                                                        367700. (F)
     WATER TREATMENT                                                      0.
     SOLID WASTE
       DISPOSAL             11010. TON/YR     $ 8.25/TON              90800.

         DIRECT OPERATING COST                                      6585900.

         PAYROLL OVERHEAD =20.0% OF A+B+C+D                           92300.
         PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                        533800.
         TOTAL OPERATING COST                                       7212000.
         OPERATING COST IN DOLLARS PER TON   PRODUCTION                  2.55
         OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED          1310.06
         OPERATING COST AS PERCENT OF CAPITAL COST                      53.8
         INSTALLATION TIME IN WEEKS                                     104.
         ESTIMATED LIFE OF SYSTEM IN YEARS                               15.
         KWH PER TON    CAPACITY                                        37.4
         CAPITAL RECOVERY (13.15% OF TOTAL CAPITAL)                 1761500.
         ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)            268000.
         PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)              268000.
         TOTAL ANNUALIZED COST - RETROFIT                           9509500.
                               - NEW                                9120300.
```

```
GENERAL INFORMATION:
                                                      UNITS    OPTION
    PPSES:  516.   QUENCHING - DIRTY WATER            COKE       4

    CAPACITY:          2.834 MILLION TONS/YEAR

    PARTICULATE
          LOAD IN:    3.200000 LBS/TON COAL
          ALLOWABLE:   .160000 LBS/TON COAL    EFFICIENCY:  95.0%
                       73.93   LBS/HR

    BSO
          LOAD IN:     .006400 LBS/TON COAL
          ALLOWABLE:   .000960 LBS/TON COAL    EFFICIENCY:  85.0%
                         .44   LBS/HR

    BAP
          LOAD IN:     .000310 LBS/TON COAL
          ALLOWABLE:   .000046 LBS/TON COAL    EFFICIENCY:  85.0%
                         .02   LBS/HR

    BENZENE
          LOAD IN:     .000260 LBS/TON COAL
          ALLOWABLE:   .000065 LBS/TON COAL    EFFICIENCY:  75.0%
                         .03   LBS/HR

    DUST COLLECTED PER DAY:       16.9 TONS(DRY)

    TEMP OUT OF PROCESS:         200. F
    EXHAUST TEMPERATURE:         200. F

    SCFM FLOW:         0.    AT    70. F
    ACFM FLOW:         0.    AT   200. F

    L/G RATIO:                      .0
    PROCESS WATER FLOW:         1213. GPM
    COOLING WATER FLOW:            0. GPM
    SUSPENDED SOLIDS OUT:       1707. MG/L      %SOLIDS:     .2
```

```
GENERAL INFORMATION:
                                                     UNITS    OPTION
    PPSES:  516.   QUENCHING - DIRTY WATER           COKE       4


    CONTROL SYSTEM CONFIGURATION:

         QUENCH TOWER BAFFLES
         COKE PLANT WASTEWATER TREATMENT


    FEET OF ADDITIONAL DUCT:              0.    DIAMETER:  0.
    TOTAL PRESSURE DROP:                  0. INCHES
    0 FANS @    0. HP EACH      SPARE FAN CAPACITY:    0.%
    OPERATING HOURS AT FULL HP:        8760.
    OPERATING HOURS AT REDUCED HP:        0.
    STACK HEIGHT:                         0.    DIAMETER:  0.
    NO. OF OVENS                         60.
    OVEN HEIGHT                          6.0 METERS
    OVEN VOLUME                        1348.  CUBIC FEET
    TONS COKE/PUSH                       24.
    AVG. COKING TIME,HRS.                17.5
    NO. CYCLES/DAY                       82.
    BULK DENSITY                         50.  LBS/CUBIC FT.
    YIELD                                 .70
    TONS COAL/YEAR                  4047868.
```

```
CAPITAL COST:
                                                   UNITS    OPTION
    PPSES:  516.   QUENCHING - DIRTY WATER          COKE        4

    CAPACITY:         2.834 MILLION TONS/YEAR

    TOTAL COST     (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4078 COS

         CATEGORY                                COST IN DOLLARS

                  *** DIRECT  COST ***
         EQUIPMENT OR MATERIAL                 3956000.
         INSTRUMENTATION                        455200.
         PIPING                                 727800.
         ELECTRICAL                             227700.
         FOUNDATIONS                            130500.
         STRUCTURAL                             130500.
         SITE WORK                              174800.
         INSULATION                             129000.
         PROTECTIVE COATING                      51800.
         BUILDINGS                              546000.
         EQUIPMENT/MATERIAL LABOR               896000.
              DIRECT COST SUBTOTAL                         7425300.

                  *** INDIRECT  COST ***
         FIELD OVERHEAD                        1059500.
         CONTRACTORS FEE                        539000.
         ENGINEERING                            842500.
         FREIGHT                                 24100.
         OFFSITE WORK                           193600.
         TAXES                                  169000.
         SHAKEDOWN                              274900.
         SPARES                                 164600.
         CONTINGENCY                           2126500.
              INDIRECT COST SUBTOTAL                       5393700.

              INTEREST DURING INSTALLATION                 1126900.

              TOTAL COST                                  13945900.

              TOTAL COST WITH RETROFIT                    17060800.
```

```
OPERATING COST:
                                                    UNITS    OPTION
     PPSES:  516.   QUENCHING - DIRTY WATER         COKE       4

     CAPACITY:            2.834 MILLION TONS/YEAR

     CATEGORY                  QUANTITY           RATE                   ANNUAL COST (

                                     *** UTILITIES ***

     WATER                           0. MGAL/YR     $  .1595/1000 GAL            0.
     ELECTRICITY               4250262. KWH/YR      $  .0266/KWH            113100.
     STEAM                     1062566. MLBS/YR     $ 4.0920/MLBS          4348000.
     FUEL                      2312143. GAL/YR      $  .4180/GAL            966500.

                                  *** OPERATING LABOR ***

     DIRECT                       8760. HRS/YR      $14.34/HR               125700. (A
     SUPERVISION                  1752. HRS/YR      $17.20/HR                30100. (B

                              *** MAINTENANCE & SUPPLIES ***

     DIRECT LABOR                20000. HRS/YR      $14.34/HR               286900. (C
     SUPERVISION                  4000. HRS/YR      $17.20/HR                68800. (D
     MATERIALS                                                              344300. (E
     SUPPLIES                                                               391100. (F
     WATER TREATMENT                                                             0.
     SOLID WASTE
       DISPOSAL                  12306. TON/YR      $ 8.25/TON              101500.

          DIRECT OPERATING COST                                            6776000.

          PAYROLL OVERHEAD =20.0% OF A+B+C+D                                102300.
          PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                              623500.
          TOTAL OPERATING COST                                             7501800.
          OPERATING COST IN DOLLARS PER TON   PRODUCTION                      2.65
          OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED              1219.26
          OPERATING COST AS PERCENT OF CAPITAL COST                          44.0
          INSTALLATION TIME IN WEEKS                                        104.
          ESTIMATED LIFE OF SYSTEM IN YEARS                                  15.
          KWH PER TON    CAPACITY                                            37.4
          CAPITAL RECOVERY (13.15% OF TOTAL CAPITAL)                      2243100.
          ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)                  341200.
          PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                    341200.
          TOTAL ANNUALIZED COST - RETROFIT                                10427300.
                                - NEW                                    9893100.
```

```
GENERAL INFORMATION:
                                                    UNITS    OPTION
    PPSES:  516.   QUENCHING - DIRTY WATER           COKE       5

    CAPACITY:          2.834 MILLION TONS/YEAR

    PARTICULATE
         LOAD IN:    3.200000 LBS/TON COAL
         ALLOWABLE:  .032000 LBS/TON COAL   EFFICIENCY:  99.0%
                       14.79  LBS/HR

    BSO
         LOAD IN:     .006400 LBS/TON COAL
         ALLOWABLE:   .000064 LBS/TON COAL   EFFICIENCY:  99.0%
                         .03  LBS/HR

    BAP
         LOAD IN:     .000310 LBS/TON COAL
         ALLOWABLE:   .000003 LBS/TON COAL   EFFICIENCY:  99.0%
                         .00  LBS/HR

    BENZENE
         LOAD IN:     .000260 LBS/TON COAL
         ALLOWABLE:   .000003 LBS/TON COAL   EFFICIENCY:  99.0%
                         .00  LBS/HR

    DUST COLLECTED PER DAY:       17.6 TONS(DRY)

    TEMP OUT OF PROCESS:        200. F
    EXHAUST TEMPERATURE:        200. F

    SCFM FLOW:  549000.   AT     70. F
    ACFM FLOW:  683000.   AT    200. F

    L/G RATIO:                      .0
    PROCESS WATER FLOW:        1213. GPM
    COOLING WATER FLOW:           0. GPM
    SUSPENDED SOLIDS OUT:      1707. MG/L     %SOLIDS:    .2
```

```
GENERAL INFORMATION:
                                                      UNITS    OPTION
    PPSES:  516.   QUENCHING - DIRTY WATER             COKE       5


    CONTROL SYSTEM CONFIGURATION:

         DRY QUENCHING
         COKE PLANT WASTEWATER TREATMENT


    FEET OF ADDITIONAL DUCT:             0.    DIAMETER: 15.
    TOTAL PRESSURE DROP:                 0. INCHES
    0 FANS @    0. HP EACH       SPARE FAN CAPACITY:   0.%
    OPERATING HOURS AT FULL HP:     8760.
    OPERATING HOURS AT REDUCED HP:       0.
    STACK HEIGHT:                        0.    DIAMETER:  0.
    NO. OF OVENS                        60.
    OVEN HEIGHT                          6.0 METERS
    OVEN VOLUME                       1348.  CUBIC FEET
    TONS COKE/PUSH                      24.
    AVG. COKING TIME,HRS.               17.5
    NO. CYCLES/DAY                      82.
    BULK DENSITY                        50.  LBS/CUBIC FT.
    YIELD                                 .70
    TONS COAL/YEAR                 4047868.
```

```
CAPITAL COST:
                                                    UNITS    OPTION
    PPSES:  516.   QUENCHING - DIRTY WATER          COKE       5

    CAPACITY:           2.834 MILLION TONS/YEAR

    TOTAL COST      (COST BASIS IS 110.00% OF JUNE 1977 DOLLARS FOR 4078 COS

         CATEGORY                            COST IN DOLLARS

                 *** DIRECT  COST ***
         EQUIPMENT OR MATERIAL         12393000.
         INSTRUMENTATION                 424400.
         PIPING                          714600.
         ELECTRICAL                      227700.
         FOUNDATIONS                     130500.
         STRUCTURAL                      130500.
         SITE WORK                       166000.
         INSULATION                      121100.
         PROTECTIVE COATING               48300.
         BUILDINGS                       546000.
         EQUIPMENT/MATERIAL LABOR       4736600.
              DIRECT COST SUBTOTAL                    19638700.

                 *** INDIRECT  COST ***
         FIELD OVERHEAD                 3398600.
         CONTRACTORS FEE                1791500.
         ENGINEERING                    1074800.
         FREIGHT                          24100.
         OFFSITE WORK                    554200.
         TAXES                           570100.
         SHAKEDOWN                       922800.
         SPARES                          192500.
         CONTINGENCY                    6379400.
              INDIRECT COST SUBTOTAL                  14908000.

              INTEREST DURING INSTALLATION             4075500.

              TOTAL COST                              38622200.

              TOTAL COST WITH RETROFIT                43553400.
```

```
OPERATING COST:
                                                  UNITS   OPTION
    PPSES:  516.   QUENCHING - DIRTY WATER     COKE       5

    CAPACITY:         2.834 MILLION TONS/YEAR

    CATEGORY                 QUANTITY         RATE                  ANNUAL COST (

                              *** UTILITIES ***

    WATER                          0. MGAL/YR    $  .1595/1000 GAL            0.
    ELECTRICITY            26918328. KWH/YR     $  .0266/KWH            716600.
    STEAM                  -1204241. MLBS/YR    $ 4.0920/MLBS                0.
    FUEL                    2312143. GAL/YR     $  .4180/GAL            966500.

                           *** OPERATING LABOR ***

    DIRECT                    17520. HRS/YR     $14.34/HR               251300. (A
    SUPERVISION                3504. HRS/YR     $17.20/HR                60300. (B

                        *** MAINTENANCE & SUPPLIES ***

    DIRECT LABOR              78337. HRS/YR     $14.34/HR              1123700. (C
    SUPERVISION               15667. HRS/YR     $17.20/HR               269500. (D
    MATERIALS                                                           676600. (E
    SUPPLIES                                                            596600. (F
    WATER TREATMENT                                                          0.
    SOLID WASTE
      DISPOSAL                 6412. TON/YR     $ 8.25/TON               52900.

        DIRECT OPERATING COST                                          4714000.

        PAYROLL OVERHEAD =20.0% OF A+B+C+D                              341000.
        PLANT OVERHEAD =50.0% OF A+B+C+D+E+F                           1489000.
        TOTAL OPERATING COST                                           6544000.
        OPERATING COST IN DOLLARS PER TON   PRODUCTION                     2.31
        OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED             1020.61
        OPERATING COST AS PERCENT OF CAPITAL COST                          15.0
        INSTALLATION TIME IN WEEKS                                         130.
        ESTIMATED LIFE OF SYSTEM IN YEARS                                   15.
        KWH PER TON   CAPACITY                                             45.4
        CAPITAL RECOVERY (13.15% OF TOTAL CAPITAL)                    5726100.
        ADMINISTRATION OVERHEAD ( 2.0% OF TOTAL CAPITAL)               871100.
        PROPERTY TAXES & INS. ( 2.0% OF TOTAL CAPITAL)                 871100.
        TOTAL ANNUALIZED COST - RETROFIT                             14012300.
                              - NEW                                  13166600.
```

APPENDIX B

EXAMPLE COMPUTER PRINTOUT FOR COST UPDATE PROGRAM

This appendix illustrates the output of the cost update program. In the example provided, the cost of Option 5, the enclosed hot car for the coke pushing source, has been adjusted by changing the cost basis from fourth quarter 1978 to mid-1979, assuming a 7 percent inflation rate. Also the cost of labor has been increased 10 percent. These increases are arbitrary and used only as an example. When the cost update program is run, one or all of the functions can be updated by using the data cards for whichever cases are to be modified.

```
                        COST UPDATE OF COKE OVEN
                          MODEL COST FUNCTIONS
                               BASIS: 2079

OPERATING COST:

                                              UNITS   OPTION
    SOURCE:      2                            COKE       5

    CAPACITY:           .272 MILLION TONS/YEAR

    CATEGORY             QUANTITY        RATE                 ANNUAL COST ($)

                          *** UTILITIES ***


    WATER                2450. MGAL/YR    $  .1600/1000 GAL          392.
    ELECTRICITY          1603. KWH/YR     $  .0266/KWH                43.
    STEAM                   0. MLBS/YR    $ 4.0920/MLBS                0.
    FUEL               258563. GAL/YR     $  .4180/GAL            108079.

                       *** OPERATING & MAINT LABOR ***


    DIRECT               8000. HRS/YR     $15.77/HR               126160.  (A)
    SUPERVISION          1600. HRS/YR     $17.20/HR                27520.  (B)

                        *** MAINT & SUPPLIES ***


    MATERIALS                                                     114800.  (C)
    SUPPLIES                                                       38600.  (D)
    SOLID WASTE
      DISPOSAL             686. TONS/YR    $ 8.25                   5659.

        DIRECT OPERATING COST                                     421253.

        PAYROLL OVERHEAD =20.0% OF A+B                             30736.
        PLANT OVERHEAD =50.0% OF A+B+C+D                          153540.
        TOTAL OPERATING COST                                      423096.
        ESTIMATED LIFE OF SYSTEM IN YEARS                             20.
        CAPITAL RECOVERY (11.70% OF TOTAL CAPITAL)                659888.
        ADMINISTRATION OVERHEAD ( 2.00% OF TOTAL CAPITAL)         112801.
        PROPERTY TAXES & INS. ( 2.00% OF TOTAL CAPITAL)           112801.
        TOTAL ANNUALIZED COST-  RETROFIT                         1308587.
                              - NEW                              1228087.
        TOTAL CAPITAL COST    - RETROFIT                         5640066.
                              - NEW                              5127333.
```

```
                    COST UPDATE OF COKE OVEN
                      MODEL COST FUNCTIONS
                          BASIS: 2Q79

OPERATING COST:

                                               UNITS   OPTION
    SOURCE:     2                              COKE      5

    CAPACITY:            .405 MILLION TONS/YEAR

    CATEGORY              QUANTITY         RATE                ANNUAL COST ($)

                            *** UTILITIES ***

    WATER                3643. MGAL/YR    $  .1600/1000 GAL         583.
    ELECTRICITY          2385. KWH/YR     $  .0266/KWH               63.
    STEAM                   0. MLBS/YR    $ 4.0920/MLBS               0.
    FUEL               384576. GAL/YR     $  .4180/GAL           160753.

                        *** OPERATING & MAINT LABOR ***

    DIRECT               8000. HRS/YR     $15.77/HR              126160.  (A)
    SUPERVISION          1600. HRS/YR     $17.20/HR               27520.  (B)

                          *** MAINT & SUPPLIES ***

    MATERIALS                                                    114800.  (C)
    SUPPLIES                                                      38600.  (D)
    SOLID WASTE
      DISPOSAL           1020. TONS/YR     $ 8.25                  8415.

        DIRECT OPERATING COST                                    476894.

        PAYROLL OVERHEAD =20.0% OF A+B                            30736.
        PLANT OVERHEAD =50.0% OF A+B+C+D                         153540.
        TOTAL OPERATING COST                                     478737.
        ESTIMATED LIFE OF SYSTEM IN YEARS                            20.
        CAPITAL RECOVERY (11.70% OF TOTAL CAPITAL)               712685.
        ADMINISTRATION OVERHEAD ( 2.00% OF TOTAL CAPITAL)        121827.
        PROPERTY TAXES & INS. ( 2.00% OF TOTAL CAPITAL)          121827.
        TOTAL ANNUALIZED COST-  RETROFIT                        1435075.
                              - NEW                             1348135.
        TOTAL CAPITAL COST    - RETROFIT                        6091328.
                              - NEW                             5537571.
                        COST UPDATE OF COKE OVEN
                          MODEL COST FUNCTIONS
                              BASIS: 2Q79

OPERATING COST:

                                                 UNITS   OPTION
    SOURCE:      2                               COKE      5

    CAPACITY:           .708 MILLION TONS/YEAR

    CATEGORY            QUANTITY         RATE                 ANNUAL COST ($)

                           *** UTILITIES ***


    WATER                6375. MGAL/YR    $  .1600/1000 GAL        1020.
    ELECTRICITY          4173. KWH/YR     $  .0266/KWH              111.
    STEAM                   0. MLBS/YR    $ 4.0920/MLBS               0.
    FUEL               672958. GAL/YR     $  .4180/GAL           281296.

                     *** OPERATING & MAINT LABOR ***


    DIRECT               8000. HRS/YR     $15.77/HR              126160.  (A)
    SUPERVISION          1600. HRS/YR     $17.20/HR               27520.  (B)

                        *** MAINT & SUPPLIES ***


    MATERIALS                                                    114800.  (C)
    SUPPLIES                                                      38600.  (D)
    SOLID WASTE
      DISPOSAL           1785. TONS/YR    $ 8.25                  14726.

        DIRECT OPERATING COST                                    604234.

        PAYROLL OVERHEAD =20.0% OF A+B                            30736.
        PLANT OVERHEAD =50.0% OF A+B+C+D                         153540.
        TOTAL OPERATING COST                                     606076.
        ESTIMATED LIFE OF SYSTEM IN YEARS                            20.
        CAPITAL RECOVERY (11.70% OF TOTAL CAPITAL)               794305.
        ADMINISTRATION OVERHEAD ( 2.00% OF TOTAL CAPITAL)        135779.
        PROPERTY TAXES & INS. ( 2.00% OF TOTAL CAPITAL)          135779.
        TOTAL ANNUALIZED COST-  RETROFIT                        1671939.
                              - NEW                             1575043.
        TOTAL CAPITAL COST    - RETROFIT                        6788936.
                              - NEW                             6171760.
```

```
                         COST UPDATE OF COKE OVEN
                          MODEL COST FUNCTIONS
                              BASIS: 2079

REGRESSION ANALYSIS:
                                                  UNITS   OPTION
   SOURCE:      2                                  COKE      5


                                                           .1938
   CAPITAL COST - NEW         = 453443.0(CAPACITY)     CAPACITY IN UNITS PER YEAR


                                                           .1938
   CAPITAL COST - RETROFIT    = 498787.3(CAPACITY)     CAPACITY IN UNITS PER YEAR


                                                           .2613
   ANNUALIZED COST - NEW      =  46504.8(CAPACITY)     CAPACITY IN UNITS PER YEAR


                                                           .2573
   ANNUALIZED COST - RETROFIT=  52125.7(CAPACITY)     CAPACITY IN UNITS PER YEAR
```